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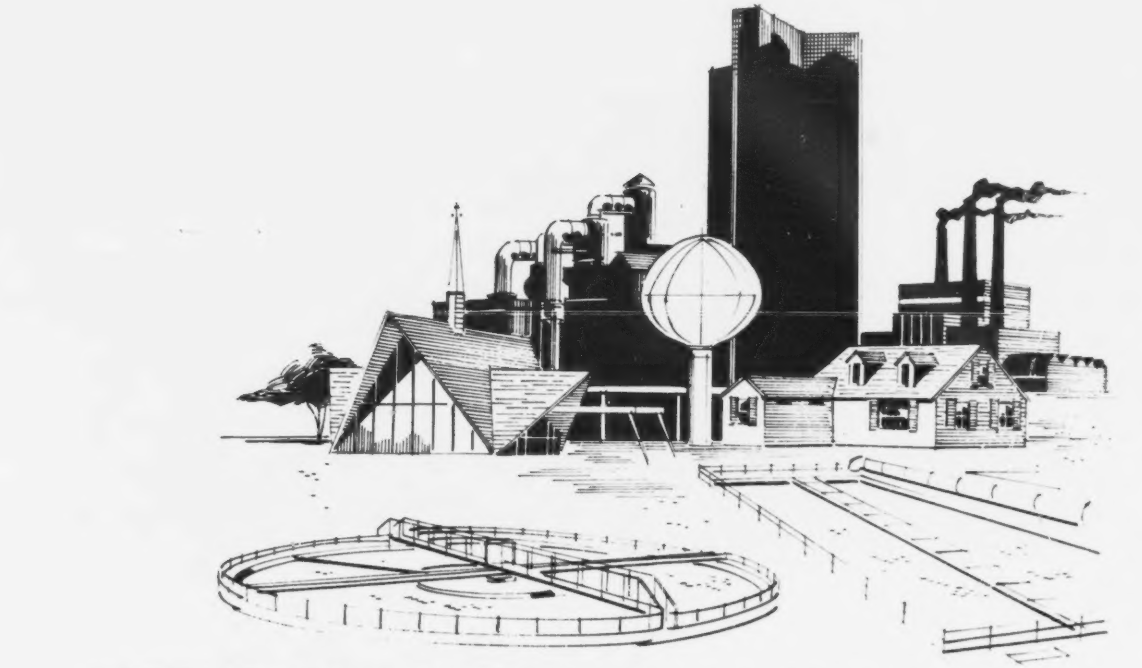

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WATER POLLUTION CONTROL

IN THE

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ABSTRACT

This report describes the accomplishments of a program conducted to organize, coordinate, and disseminate information on new or modified sludge treatment technology for water treatment plant wastes. The reliable control of these potential pollutants is of increasing importance with the enactment and enforcement of more stringent pollution control legislation. The report contains information on research, engineering, plant operation, and regulatory aspects of the problem. A Project Advisory Committee provided recommendations for development of information resources, and assisted the Research Foundation in structuring an information clearing-house. The report describes current research activities and new approaches for characterizing and reducing water treatment plant waste volumes. A program was initiated to evaluate the applicability of polymers as primary coagulants, coagulant aids, and sludge conditioning agents. A Sub-Committee was established to prepare uniform sampling, analysis, and categorization techniques for water utility sludges. Each program is in progress. Surveys were distributed to water utilities and regulatory agencies to provide information on sludge treatment methods and requirements. The AWWA Research Foundation plans the continuation and expansion of this centralized information resource program.

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SECTION I

CONCLUSIONS

1. The problem of controlling pollution caused by wastes from water treatment plants becomes a practical consideration when the discharge of of untreated wastes to a watercourse conflicts with the state and/or federal legislation prohibiting such action.

2. The reclamation and reuse of filter washwater has been demonstrated at several water treatment plants. The effects of settling this waste, and recovering and recirculating the supernatant must be examined at individual plants. Factors to be investigated in the recovery and reuse of washwater should include: the effects on the bacteriological quality of the finished water; on the other system variables and overall treatment efficiency, and on the capital, operating, and maintenance costs.

3. The utility of calcining softening sludges to recover lime for reuse or resale has been demonstrated. Individual evaluations are required to determine whether the reduction (minimization) of wastes for disposal and the recovery of lime outweigh the costs and operation considerations for such a waste treatment facility. Among the important considerations are: operation, maintenance, and capital costs for a recalcining plant; the level of operation sophistication; the extent of impure and inert material to be separated and disposed of prior to calcining; the market for excess lime produced; the recovery of carbon dioxide from the kiln for the carbonation of the product water or the carbonation of the sludge; the need to minimize air pollution in the calcining operation; and reduced main plant operating costs.

4. The possibility of recovering alum from coagulant sludges has been demonstrated. The recovery process requires careful control and operation. The recovery appears economically attractive in plants treating flows of 100 mgd or greater. Individual testing is needed to determine the value of alum recovery at specific locations.

5. Physical and chemical liquid-solid separation processes for sludge disposal require laboratory and pilot plant applications before a system can be selected.

6. Laboratory, pilot, and plant scale testing provides the basis for selecting the most efficient and economical sludge dewatering and/or recovery process.

7. The development of uniform reports on sampling, analysis, and categorization for the evaluation of wastes from all types of water treatment plants has been initiated. Standardized reporting procedures are needed for comparing data from water treatment plants. The accumulated data may illustrate seasonal variations in waste character that

are important in the orderly progression of laboratory or pilot unit testing.

8. A standard methodology to evaluate the suitability of polymers as primary coagulants, coagulant aids, and sludge conditioning agents will assist in solving the waste treatment problem. Work has been initiated to determine the utility of polymers to assist in reducing waste volume.

9. The recovery of by-products from sludge for reuse or marketing should be further investigated as an alternative to lagooning or landfill.

10. Coagulants such as $MgCO_3$, polymers, or other chemicals should be more intensively investigated. They may be suitable to replace alum, produce properly treated waters, and leave easily dewatered or treated sludges.

11. The type and amount of sludge produced in water treatment plants depends upon the raw water quality, treatment processes, and treatment efficiency. The control of these variables should be directed to maximizing waste concentration and thus minimizing of waste volume.

12. The majority of authorized regulatory agencies will require that waste effluents from water treatment plants meet existing effluent requirements and/or stream classification water quality standards before wastes can be discharged to a watercourse.

SECTION II

RECOMMENDATIONS

The development of standard testing procedures to sample, analyze, and categorize wastes from all types of water treatment plants is in progress. Following completion and evaluation, the methodology is to be submitted to an appropriate Standard Methods Sub-Committee for review and modification. It is intended that these procedures will be published in future editions of Standard Methods for the Examination of Water and Wastewater.

With the establishment of uniform reporting formats, water treatment plants should undertake the examination of their wastes as a routine operation. Records of waste quantity and quality should be accumulated and correlated to system variables such as raw water quality, treatment efficiency, temperature, and other parameters. The collection of this data is an important first step in selecting sludge dewatering or by-product recovery technology for laboratory or pilot scale evaluation.

The utility of polymers or some universal coagulant to favorably alter waste character and minimize waste volume should be demonstrated at specific treatment plants. The suitability of polymers to replace or reduce alum or ferric salts in the production of potable water and to make sludges more amenable to dewatering must be fully resolved. A methodology is under development to systematically evaluate and choose effective polymers.

The results of research and demonstration projects on techniques to recover and reuse filter washwater, to recover solid wastes for reuse or marketing, and to utilize new or modified liquid-solid separation processes should be collected by the AWWA Research Foundation. The need for water utility oriented organizations to provide reports of individual research is evident for the success of a central information resource. As a clearing-house, the Foundation will organize, coordinate, and transfer reports on research and new technological developments, such as the use of magnesium carbonate to remove color and turbidity from water and the rotary precoat vacuum filtration of alum sludge, to the water utility industry.

The design of new or modified water treatment facilities should incorporate integrated water and waste treatment processes having the flexibility to adjust to changes in the sludge character.

Laboratory, pilot, and plant scale investigations are invaluable in determining the most suitable sludge treatment sequences at specific utilities. The most economically justifiable sludge treatment alternative must provide the basis for the final process selection. It is expected that heavily populated areas will require the investigation of by-product recovery or dewatering procedures utilizing minimum area requirements for ultimate disposal. Areas not heavily populated may still use sedimentation or lagooning procedures to treat wastes. The record of chemical constituents in particular sludges may justify the use of recovery processes.

Each water utility must consider the effects of recycling highly treated washwater to the intake line of the treatment facility. Bacteriological and other quality and treatment efficiency evaluations must be made. The recovery of this water may lower plant operating costs and reduce pollution caused by the discharge of this waste to a watercourse.

The climatological conditions of a specific geographic area must be fully exploited in waste treatment. The natural freezing and thawing of purification sludges in lagoons will reduce the solids to a coffee ground formation that settles well and occupies a minimum volume. These settled solids can be used as the first step in alum recovery operations. Other possibilities such as the use of solar evaporation ponds in arid regions to treat concentrated brine wastes, must be part of an overall treatment sequence.

The selection and operation of water treatment processes affects the nature of the waste. Processes must be chosen that make wastes amenable to handling and treatment.

Some water treatment facilities do not presently have sludge disposal problems. It is expected that these utilities will plan future treatment alternatives that can alleviate or lessen the problems when they become real. For instance, two raw water supplies may be available for development. One source may require significant pumping before reaching the plant. The second source may be nearby. The first source may be relatively higher in quality than the second source. If the source further away will produce considerably less waste, the cost of pumping this water and treating this waste should be compared with the cost of pumping the closer raw water supply and treating its waste before a selection is made.

The true effects of discharging softening and purification wastes to sewage treatment systems must be fully explored. The effect of sludges on settling efficiency in primary settling tanks and removing phosphate in activated sludge processes is relatively unknown. These solid wastes will increase digestor requirements. The efficiency of a digestor should be tested with varying amounts of water plant sludge added to the basically organic sewage wastes.

Sludge incinerators, with adequate particulate emmission removal systems which minimize air pollution, must be investigated. The residue from incineration can be used as a landfill and may demonstrate utility as an aggregate for concrete.

The hydraulics of transporting purification and softening sludges in pipelines needs reasearch. Pumping, head loss, and floc disintegration must be included in this area of study.

Modifications to new or existing processes available from other industries should be developed. The Metroplitan Water District of Southern California modified the alum recovery operation used in Tokyo by incorporating filter pressing to separate the recovered alum sulphate solution from the acidified inert sludge.

Research on the recovery and treatment of concentrated brine solutions must be considered so that the use of ion-exchange and desalination processes will be possible without violating state and federal pollution control requirements.

The effect of regionalizing treatment systems for producing potable water and handling wastes in contiquous operations must be considered. Several basin commissions have been formed to determine legitimate water utilization and water pollution control measures. The regional approach applied to water treatment plants might require more sophisticated operation and management.

In large water treatment plants where the recovery of alum may be practicable, special personnel may be required to operate the recovery facilities. Chemical suppliers might be interested in operating this facility. The recovery process may not be economically lucrative when first compared to the price of new alum, but alum recovery minimizes the amount of waste for ultimate disposal.

Water utilities must keep abreast of state and federal legislation, such as the Harbors and Rivers Act of 1899, that may require each treatment plant to file discharge permits with the U.S. Army Corps of Engineers.

SECTION III

INTRODUCTION

The need to successfully handle and dispose of wastes from water treatment plants has attained increased importance. More stringent pollution abatement legislation is being enacted to deal with wastes from all types of industrial sources. Public awareness of controlling pollution caused by municipal and industrial discharge of waste streams to watercourses is emphasized in the various communication media. The wastes from water utilities are classified as industrial in character. There is an opportunity for the water treatment industry to be the first major industry to control their wastes on a national scale.

The AWWA Research Foundation, in 1969, published a state-of-the-art report on the "Disposal of Wastes from Water Treatment Plants." This study was supported in part by a grant from the FWPCA. It presented known treatment technology, cost data, and suggestions for future needs. The report recommended the establishment of a central information clearing-house to organize, coordinate, and disseminate information on new or modified treatment technology and promote its application by the water utility industry.

The Research Foundation, in 1970-71, conducted an expanded program titled "Information Resource on Water Pollution Control in the Water Utility Industry." This study was supported by a grant from the Water Quality Office, EPA, and by matching funds from 30 water utilities. Implementation of the project has developed activities for the transfer of technology among researchers and water utilities, and has defined gap areas of treatment technology requiring further investigation.

A Project Advisory Committee, composed of experts involved in the research, engineering, plant operation, and regulatory aspects of the sludge disposal problem, was assembled for a two day meeting. The purpose of the meeting was for Committee members to exchange ideas and present recommendations to aid the Research Foundation in organizing an information service. The preparation of two surveys and the presentation of several reports on aspects of the sludge treatment problem were undertaken.

The need was recognized for an information clearing-house to initiate laboratory or pilot scale investigations of sludge dewatering and by-product recovery processes. The accumulation and dissemination of current research information is a valuable step in providing criteria for solution of specific problems at individual water utilities. The report is intended to aquaint the water utility industry with references to past, present, and proposed work as bases for the adoption of waste treatment programs.

Research and development activities were identified through governmental agencies, literature searches, and personal correspondence with

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water research institutions. Technical articles were abstracted in accordance with Water Resources Science Information Center specifications for inclusion into their computerized storage and retrieval system. Abstracts in section 5 of this report are capsule summaries of new material acquired since the 1969 Research Foundation report. Section 9 summarizes information from historical articles tracing the development of presently utilized sludge disposal techniques.

Surveys were distributed to authorized regulatory agencies and water treatment plants. The results reported in regulatory surveys provide new information on the parameters to be considered for treatment requirements; acceptability of sludge disposal methods; maintenance and reporting of waste production records and the support and conduct of research. The water utility surveys demonstrate the need for standard documents to sample, analysis, and categorize basic waste quantitative and qualitative data.

Several new approaches have been developed to establish means of: comparing data from water utilities; reducing waste volume and increasing waste concentration; and inventorying the equipment available for treating waste sludges. A project Sub-Committee is actively involved in developing standard sampling and analysis documents for wastes from all types of water treatment plants. A polymer evaluation program has been initiated to determine the applicability of polymers as primary coagulants, coagulant aids, and sludge conditioning agents.

The publication of new information should further stimulate the direction and support of research into areas of needed investigation. There is no universal solution for the treatment of water purification and softening sludges but, rather, a variety of alternative methods. Treatment alternatives will require evaluation based on local situations, and will involve studies of efficiency, operation and maintenance requirements, and economics.

Process Development and Applicability

Several major sludge treatment processes were suggested by the Project Advisory Committee and the Research Foundation to be incorporated into the manual Research & Development system. These treatment alternatives are arranged alphabetically in Table 1 titled "Processes for Treatment, Disposal, and By-product Recovery of Water Treatment Plant Wastes." The state of development and applicability of each process are identified on the basis of the references utilized. This listing is not intended to be all inclusive, but to summarize the information accumulated in this specific study.

The utility of conducting laboratory, pilot, and plant scale evaluations of new or established sludge treatment technology cannot be overemphasized. Waste character can vary significantly from treatment facility to treatment facility. The study of new or modified technology on laboratory or pilot scale aids in the development of physical and chemical design parameters. The systematic evaluation of alternative treatment methods is an important step in avoiding major deficiencies in the design and construction of plant scale facilities.

TABLE 1

PROCESSES FOR TREATMENT, DISPOSAL, AND BY-PRODUCT RECOVERY OF WATER TREATMENT PLANT WASTES

Process	State of Development	Applicability
Alum Recovery	Laboratory, Pilot, and Plant Scale	Alum Sludge
Centrifugation	Pilot and Plant Scale	Lime and Lime-Soda Sludge Alum Sludge Polymer Conditioned Sludge Filter Washwater Sludge
Chemical & Polymer Conditioning	Laboratory, Pilot, and Plant Scale	Alum Sludge Lime and Lime-Soda Sludge Filter Washwater
Drying Beds	Pilot and Plant Scale	Alum Sludge Lime and Lime-Soda Sludge Polymer Sludge Filter Washwater Sludge
Filter Pressing	Pilot and Plant Scale	Alum Sludge Lime and Lime-Soda Sludge Polymer Conditioned Sludge Filter Washwater Sludge
Freezing	Laboratory, Pilot, and Plant Scale	Alum Sludge
Lagooning	Pilot and Plant Scale	Alum Sludge Lime and Lime-Soda Sludge Polymer Conditioned Sludge Ferric Hydroxide Sludge Filter Washwater Sludge
Lime Recovery	Pilot and Plant Scale	Lime and Lime-Soda Sludge
Magnesium Carbonate Recovery	Laboratory, Pilot, and Plant Scale	Lime and Lime-Soda Sludge
Recycling	Pilot and Plant Scale	Alum Sludge Lime and Lime-Soda Sludge Polymer Conditioned Sludge Filter Washwater

TABLE 1 (continued)

Process	State of Development	Applicability
Recycling	Pilot and Plant Scale	Alum Sludge Lime and Lime-Soda Sludge Polymer Conditioned Sludge Filter Washwater
Sedimentation	Pilot and Plant Scale	Alum Sludge Lime and Lime-Soda Sludge Polymer Conditioned Sludge Ferric Hydroxide Sludge Filter Washwater
Vacuum Filtration	Laboratory, Pilot, and Plant Scale	Alum Sludge with Conditioning or Precoat Lime and Lime-Soda Sludge
Miscellaneous		
Neutralization and Precoat Filtration	Evaluation-Pilot Scale	Acid Mine Drainage Waste
Thickening-Dewatering	Detailed Study	Acid Mine Drainage Waste
Evaporation Ponds	Laboratory and Pilot Scale	Desalting Concentrated Brine Streams
Brine By-Product Recovery	Conceptual Design	Desalting Concentrated Brine Streams
Evaporation-Well Disposal	Developmental	Zeolite Softener Brines
Sewage Treatment Coagulant	Laboratory and Plant Scale	Lime and Lime-Soda Sludge

Section XIII of this report contains the references used in the development of the information resource program. The references are arranged alphabetically by author and numbered consecutively. The following processes and references provide a basis for individual investigation.

Alum Recovery

The recovery of an aluminum sulfate coagulant from purification wastes containing appreciable aluminum content has been utilized on a plant scale basis both in France and Japan. The acidification of a basically aluminum hydroxide waste produces a soluble reuseable coagulant and inert material. The process can substantially reduce the waste volume for final disposal, but requires a more sophisticated operation and management than physical thickening processes. Other important considerations in this technology are the efficient separation of recovered alum solution from the inert material unaffected by acidulation and the minimization of impurities such as iron and manganese building up in the recovered solution. The following reference numbers apply to the investigation of alum recovery on laboratory, pilot, or plant scale level: 9, 15, 22, 27, 33, 38, 39, and 92.

Centrifugation

The centrifugation of waste sludges from purification or softening facilities physically changes the solids concentration of the feed stream. Centrifugation can be employed as a major process to produce a waste concentrate suitable for landfill or can be one unit process in a sequence to prepare the waste for by-product or additional dewatering. The use of polymeric or inorganic conditioners appears to be beneficial in the centrifugation of purification waste. Pilot and plant scale activities of centrifugation investigations have been identified. The reference numbers include: 1, 9, 14, 20, 25, 28, 33, 54, 57, 58, 69, 72, 88, 92, 95, and 98.

Chemical and Polymer Conditioning

The conditioning of wastes by the application of inorganic or organic materials can assist in increasing the dewaterability rate and additionally concentrating waste solids. Conditioning agents can be applied to waste streams to prepare these streams for dewatering by physical separation techniques such as centrifugation, drying beds, filter presses, and vacuum filtration. Some polymers have demonstrated suitability, in specific instances, of replacing the inorganic coagulant to produce a concentrated waste amenable to dewatering. Development at laboratory, pilot and plant scale levels is still needed in this area. The references applying to the conditioning of waste volumes include numbers: 1, 9, 13, 17, 18, 46, 53, 68, and 97.

Drying Beds

The successful dewatering of waste sludges on drying beds is in part dependent on the climatological conditions of the region and the character of the waste sludge. The use of polymers to form a bridge between floc particles from alum coagulation processes may enhance the dewaterability of these difficult to treat sludges in this process. The efficiency of drying beds to produce a concentrated waste for final disposal should be developed carefully to determine the specific design parameters applicable at each water utility. Literature reference to drying beds include numbers: 7, 9, 18, 50, 52, 56, 57, 83, 92, and 96.

Filter Pressing

The use of filter presses to dewater wastes from purification and softening processes has been developed on plant scale bases in England and other parts of Europe. Plant scale presses are under construction in both Atlanta, Georgia, and Little Falls, New Jersey. Detailed laboratory and pilot plant testing of filter pressing determines parameters for final design. Some manufacturers of filter pressing equipment for sewage treatment plant waste have informed the Research Foundation that experimental work is underway to determine the suitability of this equipment for dewatering water utility wastes. Literature references to filter presses include numbers: 5, 9, 12, 13, 17, 25, 26, 33, 35, 46, 57, and 94.

Freezing

The natural freezing of aluminum hydroxide sludge has been utilized by the Copenhagen Water Department on a plant scale level. Natural and artificial freezing has undergone detailed development in England. The freezing and thawing process physically alters the character of aluminum hydroxide wastes. A continuous slow freeze of these waters aids in releasing the water of hydration from purification wastes. The solids settle rapidly upon thawing, assuming a coffee ground type of consistency. Work in the United States is in laboratory and pilot stages both for artificial and natural freezing processes. Literature references to freezing include numbers: 9, 14, 15, 17, 19, 25, 26, 27, 33, 34, 39, and 57.

Lagooning

The separation of solid wastes from the supernatant waste can be accomplished in a well designed and operated lagoon. The settling of purification and softening wastes in lagoons requires substantial land areas when compared with mechanical or chemical dewatering processes. The lagoons can function as sludge thickeners, as solid material is concentrated over long retention periods. Cyclic cleaning of lagoons may be required, and the solid material may be used as landfill or for other purposes. Literature references to lagoon operations include numbers: 3, 5, 6, 7, 8, 9, 15, 25, 37, 39, 50, 57, 63, 64, 65, 78, 83, 92, and 96.

Lime Recovery

The production of lime from calcium carbonate softening sludges eliminates the major need for final disposal of softening plant wastes. In addition, operating costs can be lowered by selling the excess lime produced. The separation of impurities such as iron, manganese, magnesium, and inert matter must be accomplished so that only the most pure calcium carbonate is recalcined. Plant scale applications of recalcining have been fully accomplished in the United States. Plant scale operation should follow extensive laboratory and pilot stage evaluation. Literature references to lime recovery include numbers: 4, 6, 7, 9, 20, 33, 41, 44, 47, 48, 55, 58, 70, 73, 77, 85, 88, 92, and 98.

Magnesium Carbonate Recovery

The recovery of lime from softening sludge is a major technology that can alleviate the solids disposal problem existing at lime or lime-soda softening plants. To achieve a high grade lime product, impurities such as magnesium must be removed. Carbonation of softening sludge containing appreciable magnesium hydroxide can dissolve the insoluble magnesium salt. The soluble magnesium carbonate can be physically separated from the calcium carbonate precipitate. The utility of magnesium carbonate as a purification plant coagulant to replace alum is being evaluated at the Montgomery, Alabama, water treatment plant. Literature references for magnesium carbonate recovery include numbers: 16 and 28.

Recycling

The recycling of waste supernatant from filter washwater operations may be economically justifiable on the basis of the recovered water and the pollution control need. The suspended solids in filter washwater may provide sites for initiating the coagulation and the agglomeration of floc particles. High rate clarification units also may utilize a recycled sludge to provide nuclei for floc formation. Literature references for recycling include numbers: 9, 37, 44, 48, 59, 81, 86, 90, 92, and 97.

Sedimentation

The settling of wastes from filter washing and sedimentation tank cleaning may provide a good approach to additional thickening of the sludge and the recovery of the supernatant. Sedimentation can be accomplished in basins constructed of various material. Literature references for sedimentation include numbers: 9, 23, 24, 37, 39, 50, 55, 63, 78, and 81.

Vacuum Filtration

The dewatering of both purification and softening wastes has been accomplished through vacuum filtration. Softening wastes require little or no conditioning prior to dewatering on the vacuum drum. Alum wastes may require preconditioning with various materials. Pilot work is underway using a rotary precoated vacuum filter to dewater alum sludge. Literature references to vacuum filtration include: 1, 4, 5, 8, 9, 11, 14, 17, 23, 25, 31, 33, 39, 47, 48, 55, 56, 57, 62, 69, 92, and 96.

Miscellaneous

Studies dealing with the treatment of acid mine drainage, desalting plant brines, zeolite softener brines, and the use of lime and lime-soda sludges as sewage treatment coagulants have been identified in this study. Reference numbers 62 and 69 deal with the neutralization and precoat filtration and thickening of acid mine wastes respectively. Literature dealing with the evaporation and by-product recovery from desalting brines include reference numbers 29, 30, 36, 40, 42, 60, 66, 80, and 91. Reference numbers 7 and 75 consider the evaporation well disposal of zeolite exchange softening brines. Reference numbers 6 and 75 consider the use of softening wastes as coagulants for sewage treatment plant use.

SECTION IV

ADVISORY COMMITTEE RECOMMENDATIONS

Introductory Statement

The AWWA Research Foundation conducted a study in 1968-1969 on the "Disposal of Wastes from Water Treatment Plants." The comprehensive report was published under that title as Water Pollution Control Series, ORD-2, by the Federal Water Pollution Control Administration, U.S. Department of the Interior. The report was also published serially in four issues of the AWWA Journal.

The Foundation's study was comprised of four status reports on research, engineering, plant operations, and regulatory aspects, and a review of current technology and costs. The final report recommended that "substantially expanded programs of research and demonstration be undertaken" and included lists of specific problems in need of investigation to develop effective and economical technology.

The Project Advisory Committee for that study recommended the establishment of a central service to promote the planning of research and development, and to implement new programs. The service was proposed to organize, coordinate, and disseminate information on new or modified treatment technology to control pollution from water treatment plants. The transfer of this technology is needed to promote its application by the water utility industry of the United States.

A central information service has been established. The program, titled "Information Resource on Water Pollution Control in the Water Utility Industry," is jointly funded by the Water Quality Office of the Environmental Protection Agency and by matching funds contributed by 30 U.S. water utilities. The contributions from water utilities to support the development of new and important technical information represents an expression of confidence in the usefulness of the program.

Project Advisory Committee

The Research Foundation assembled individuals concerned with various aspects of the water utility industry to advise and guide the Foundation in its information resource program. Members of the Committee were selected to include the Chairmen of two AWWA Committees: the Water Quality Division Committee on Water Treatment Plant Waste Disposal, and the Research Committee on Sludge Disposal. The Committee also included four members who served in the project on "Disposal of Wastes from Water Treatment Plants," and four new members.

The Advisory Committee provided the expertise to assist the Research Foundation in defining the dimensions and directions of the study to collect, evaluate, and distribute the information required.

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Status reports on the activities of the two AWWA Committees were presented. The Foundation staff summarized the goals of the information resource program. The research plans were prepared under three principal areas: the organization, coordination, and communication of information.

Research Foundation Goals

The Research Foundation assisted by the Advisory Committee planned to:

1. Publicize current regulatory, research, engineering, and operating practice procedures and to encourage the submittal of information from manufacturers of equipment and supplies applicable to the study. Also, to encourage questions by water utility manufacturers that provide the basis for additional research and/or development.

2. Present to research, engineering, operating practice groups, and manufacturers, those sludge treatment and disposal techniques requiring further development.

3. Encourage initiative among the various water utility trade organizations to develop novel approaches for sludge treatment and disposal.

The critical analysis of information prepared by the Foundation, and methods to improve the analysis and translation of information into a useable form, is an essential Advisory Committee function. Disseminated information should be designed for use at all levels of operation.

Recommendations for additional information to supplement existing information and the presentation of problems existing in current operations and possible solutions by the Advisory Committee will provide direction for the Foundation's study.

Experience in Organization of Information

The Research Foundation, as a central information resource, planned the identification and inventory of research and demonstration projects. Several sources were searched to obtain information on projects completed, in-progress, or projected. The sources included: Science Information Exchange; Water Quality Office of the E.P.A.; Office of Saline Water, USDI; municipal water utilities; educational institutions; manufacturers of equipment and supplies; engineers; and foreign institutions.

The status of research and demonstration projects identified through each of these sources was developed by correspondence with principal researchers. Available publications and reports collected are classified in accordance with a manual Research & Development Information Storage & Retrieval System. A copy of this system is contained in the report appendix.

A basic data survey was prepared by members of the operating practice group of the Advisory Committee. The purpose of this survey was to inventory basic data on the quality and quantity characteristics of wastes from water treatment processes, and on their pollutional effects. A copy of this survey, prepared for distribution to water utilities, is included in the report appendix.

Additional information sources included the AWWA Research Committee on Sludge Disposal and the Water Quality Division Committee on Water Plant Waste Disposal, other committees performing related work, and development needs identified by others.

Various processing industries were suggested as having waste disposal problems whose methods could be converted into the water utility field. The results of research from manufacturing organizations may provide new or modified approaches to waste treatment technology.

The sections of the AWWA were recommended as a source of information on research and demonstration projects. Although few sections have research committees, the publicity of the information resource program at the section level could stimulate the submittal of information on research activities.

Members of the regulatory group prepared a survey to be distributed to state regulatory agencies. The purpose of this survey was to provide information on statistical, research, and regulatory aspects of the waste treatment process. A copy of the regulatory survey is included in the report appendix.

The Advisory Committee recommended the development of uniform sampling, analysis, and categorization techniques for water treatment plant wastes as an immediate priority. The orderly development of reliable waste quantity and quality data is dependent on standard test procedures. Variations, in a recent survey, have proven significant due to the sampling and/or analysis methods.

The Committee recommended the future funding of pilot and plant scale demonstration facilities. The project conducted by the Research Foundation will allow better justification for providing funds in this area. The priority need must be demonstrated before these projects are federally supported. Demonstration on pilot plant scale is a definite need since, if there is much more delay in funding research, plant scale processes will be built. Meaningful suggestions for priority research will illustrate the need for increased funds to be made available for treating water plant wastes.

Coordination of Information

The program is dynamic in nature. Practical applications of waste disposal technology must be presented to scientists, engineers, and administrators in a useable form. Data must constantly be analyzed, translated, and supplemented to facilitate its application in research and demonstration projects.

The exchange of information between those who develop and those who apply new information often requires translation. Through the development of a central information resource for pollution control in the water utility industry, the Research Foundation plans to stimulate communication between research organizations and water utilities to develop the required technology.

Prime emphasis in this study was given to the development of treatment process modifications. These modifications may result in wastes of different quantity or quality characteristics, thus affecting waste volumes and treatability. Pollution control processes and procedures must be established to meet the constantly changing stringent requirements of federal and state regulatory agencies.

Communication of Information

Communication of information is essential to a diverse cross-section of individuals and organizations. The water utility industry can benefit by learning the newest developments in waste treatment practices. Research workers will find important direction in investigating water utility waste problems while learning of current research programs.

In this way, duplication of programs can be avoided and money and time channeled into new programs. Consulting engineers will have the needed data to design water treatment plant waste control units. Manufacturers will have avenues to develop products that will be immediately needed, and incentive and direction to develop new process equipment and supplies.

The Foundation planned assistance for the design of research and demonstration projects to assure the wide applicability of all types of information developed. Reports defining specific research topics will be published. Basic and applied research results must be reported with the degree of their applicability.

Special Reports by Advisory Committee Members

Report of AWWA Committee Activities. The Water Treatment Plant Waste Disposal Committee (AWWA Water Quality Division) activities were reported by Lee Streicher, Chairman.

This Committee was formed with a scope to study and report the problems and methods of disposal of water treatment plant wastes considering:

a. Disposal of filter washwater and sludges
b. Disposal of brines

The Committee was originally composed of 10 members, including the Chairman, and was divided into 5 different subject sections as follows:

1. Disposal of Filter Washwater
2. Disposal of Lime-Soda Sludge

3. Disposal of Alum Sludge
4. Disposal of Other Coagulant Sludge
5. Disposal of Brines

The preliminary report of this Committee stresses certain objectives that must be considered. Initially, the amount of waste produced should be reduced by the careful selection of an appropriate treatment method. After waste reduction is acheived, concentrated efforts should be directed to finding an easier sludge disposal form. As an example, it is suggested that polyelectrolytes replace alum as a coagulant. The polyelectrolyte sludge is more easily dewatered.

Mr. Streicher is presently dealing with Colorado River water that has required only intermittent coagulation. A new plant is under construction to process a different supply source which will require continuous coagulation with alum. Without adequate lagooning area, other alum sludge disposal means must be considered.

Other treatment alternatives entertained were alum recovery, discharge to quarries, and discharge to sanitary sewers. The discharge of sludge to sanitary sewers was initially rejected by the Bureau of Sanitation. After some thought, the Bureau reconsidered this proposal since the sludge transport water would enhance the quality of their source water from sewage treatment plants. Further study by the Bureau showed that the water treatment plant sludge would add significant bulk to their own sludge and also make the sewage sludge harder to dewater. Digestor capacity would have to be increased, and the water utility would have to pay for the resulting increases in the water reclamation plant digestion units due to the presence of the alum sludge.

The development of by-products from waste sludges was also presented. Lime and alum recovery were cited as reclamation processes. Reference was made to Peter Doe's paper on lime sludge reclamation, and the possibility was raised of developing uses for lime or alum.

If by-products cannot be recovered, the methods of final disposal should be improved. Efficient dewatering and sludge incineration techniques should receive further investigation.

There is a great need for the standardization of sampling, analysis, and categorization techniques for sludges at water treatment plants. To make any data meaningful and applicable, standardization is essential.

Finally, Mr. Streicher discussed the contribution such a Committee would make to resolving the sludge disposal problem. Rather than enumerate or reference sludge treatment and disposal processes, this Committee would discuss processes such as the handling of lime or alum sludges or the recovery of products from sludges. This would provide concerned individuals with methods of handling different problems in a step-by-step fashion.

Discussion of Committee Report. Several points were made regarding the report on water treatment plant waste disposal. The control of waste quantity was questioned. The concentration of the material produced was suggested as being under control of the water plant operator.

The amount of wastes produced is under control if the coagulant is a polyelectrolyte and not alum. Not only is the waste concentrated, but its nature is changed. Studies have shown that 1.0 to 1.25 ppm of polymer is equivalent to 20 to 25 ppm of alum.

Total control of sludge volume and quantity is not always possible. These values cannot be controlled when softening water to a certain residual hardness and removing turbidity to predetermined finished water levels. The softening process produces calcium carbonate and removes suspended material from water. These solids cannot be reduced. A change of chemicals in the clarification system may aid in changing the volume produced.

The Committee report refers to a plant which softens Colorado River water by ion exchange. The new supply being developed at this utility will require clarification only.

The question of taste and odor problems arose concerning the waters in question. Carbon is not used, although there were infrequent taste and odor problems with the Colorado River water. Taste and odor are generally small in magnitude. A system has been developed to control taste and odor and bacteria. Due to bird droppings, the bacterial count of water going to the filters was several times higher than the count of the raw water. A three-step chlorination process was developed and odors were controlled. The new supply source will introduce a color problem. Among the experimental methods being studied for color removal is the use of ozone. Ozone reduces color effectively and does a fine job of preliminary sterilization. Instead of prechlorination, an ozonation step could possibly be used. The reduction of waste volume should be a primary goal if possible.

The treatment facility mentioned in the Committee report has successfully utilized Catfloc and Nalcolyte 607. These polymers produce a fine but suitable floc. However, the floc required a nonionic to produce weight for settling. A dosage of 0.20 to 0.25 ppm of Magnifloc 985 along with 1ppm of Catfloc or Nalcolyte 607 does a good job. The need for investigation of polymers to reduce waste volumes is evident.

Report of Research Activities. Research activities were reported by R.N. Kinman. Most of the work I am aware of now deals with the recovery of useable material from lime-soda sludges and the conditioning of alum sludges through the use of polymers.

Dr. Black has in progress at the City of Dayton, the University of Florida at Gainesville, and Montgomery, Alabama, projects dealing with the recovery of magnesium from water softening plant sludges. The process plans to recover magnesium, which in turn, can be recycled as a coagulant. A patent is involved with this particular research. It is also proposed to study use of the magnesium recovered at Dayton as a coagulant at the local sewage treatment plant for phosphorus removal.

At Virginia Polytechnic Institute work is being done on the conditioning of alum sludge with polymers. Nonionics of relatively high dosages appear to be most effective.

Several water treatment plants are experimenting with their sludges attempting to make them more amenable to dewatering. Research work is being done with sludge from the Cincinnati Water Treatment Plant at the plant and at the University of Cincinnati. Investigators have shown that polymer addition to this sludge has increased the dewaterability characteristics of the sludge.

A number of priorities should be established under research needs. The foremost need is to develop a standardization of sampling, analysis, and categorization techniques for sludge. With the development of a standard method, there would be a basis for comparison of sludge wastes. It was pointed out that several plants do not presently recycle filter washwater and that such recycling could decrease the volume of wastes produced. The reduction of waste volume is an important consideration. Polymers may applicable in reducing waste volume, although they are sensitive. There is no universal polymer available at this time. Laboratory methods should be carefully considered, since detergents contain anionic surfactants that neutralize the polymers. Polymers should also be fresh and stored in glassware that must be aged. Finally, in recovering or reusing products from sludge, a market is needed to make the operation meaningful. The City of Dayton has a market survey underway to determine buyers and the price of recovered magnesium.

Discussion of Research Activities Report. If there are interfering substances in the water due to detergents or other contaminants,methods to destroy these interfering substances economically should be explored before searching for the right polymer.

Polymers are quite expensive. The turbidity of an average water, however, can be removed with parts per billion of polymer as opposed to parts per million of alum. Polymers have a variable price range. The Catfloc ranges in price from 40 to 50 cents per pound. The Nalcolyte ranges in price from 30 cents per pound for tank car lots to 40 cents per pound for small quantities.

Polymer prices may go down in time. There are not many water treatment plants using polymers at this time. There is experimentation in progress and a large numbers of polymers have been approved by the Public Health Service for water treatment plant use. Few water treatment plants have the time to investigate all the approved polymers.

Quality control in polymer production was mentioned. Polymers must be purified and consistencies insured before approval can be granted. The elimination of trace byproducts and consistent production quality are essential.

It appears that the more polymers are used, the lower will be the cost and more consistent the product. Manufacturers will have experience in producing polymers. It was recommended to use polymers wherever they fit into the treatment process.

SECTION V

INFORMATION RESOURCES AVAILABLE

The Project Advisory Committee was requested to recommend specific information needs and resources. The Committee members were assigned topics dealing with research, engineering, regulatory, and plant operating practice aspects of this problem.

Research Needs - R.N. Kinman

A review of the first report, "Disposal of Wastes from Water Treatment Plants", showed what was known. The Research needs were spelled out in the AWWA Conference report. These needs were grouped under four headings. The headings were: Nature of Wastes, with 4 problem areas; Treatment of Water Plant Wastes, with 15 problem areas; Ultimate disposal of Wastes, with 7 problem areas; and Future Water Treatment and Waste Management Technology, with 5 problem areas.

Several projects have been proposed or are in progress to obtain information related to the solution of these problem areas enumerated in the Conference report.

The following agencies or individuals should be contacted to obtain as a full report as possible on what is known at the present time and the specific objectives of each project. The list is as follows:

a. A.P. Black, University of Florida at Gainesville
b. Walton Farr, City of Dayton, Ohio
c. George Webster, Water Quality Office of EPA
d. City of Atlanta, Howard Peters
e. Clifford Randall Virginia Polytechnic Institute
f. Paul King, Virginia Polytechnic Institute
g. Office of Water Resources Research
h. Sharples Centifuge Company
i. Bird Centrifuge Company
j. Rex Chainbelt Company
k. Ralph Evans, Illinois State Water Survey
l. Lee Streicher, Metropolitan Water District of Southern California.

When information is reviewed, it should be reported to the industry in Willing Water, the AWWA Journal, and in a Research Foundation publication. When information is reported, its relation to the whole or partial solution of one of the problems should be indicated along with the research needs still to be met. This procedure would keep everyone abreast of what is known and at the same time call attention to the work remaining to be done.

Since much of the usefulness of the data developed by the Research Foundation depends on basic data concerning the first grouping, Nature of Wastes, which has been generated by performing standardized analyses for the same parameters, on wastes from different plants, it is essential that this Committee develop and promulgate standard methods of analysis for water treatment plant wastes. After these have been evaluated and approved, the methods should be furnished to the water utility industry with the basic data questionnaire attached. Then data would be generated that could be compared in a meaningful way.

The priorities in research are as follows:

1. Uniform sampling procedures and standard methods of analysis.
2. Recycle of waste waters.
3. Reduction of waste volumes.
4. Recovery of valuable materials from waste either for reuse or sale.

Discussion of Research Needs

The need for the development of basic data on waste quantity and quality was emphasized. Standardized sampling, analysis, and categorization techniques should be developed to effectively compare data from water treatment plants.

The ultimate goal will be to have these uniform techniques submitted to the appropriate Standard Methods Sub-Committee for review. The Standard Methods Sub-Committee may suggest additional techniques and consider the incorporation of this work into their publication. The final methods may result from modification to existing approved methods that have been successfully utilized for agricultural, soils, or other analysis fields.

A Sub-Committee composed of Messrs. Herbert Hartung, Kenneth Shull, Ralph Evans, and Riley Kinman was organized to suggest appropriate modifications to existing sampling and analysis techniques that would then be applicable to water treatment plant wastes. The Research Foundation is to coordinate the exchange of information. Each member is to suggest standards for lime softening and alum sludges that could be exchanged for review and comments. Standards should be considered for brine sampling and analysis procedures. This program has been implemented.

Engineering Needs - G.P. Fulton

The role of the engineer is to translate scientific data into a form that is both useable and practical. The research needs of the engineer are consistent with those outlined earlier by Riley Kinman. We are planning to develop future data, but the time for the engineer is now. The states have arbitrary standards at present for treating water treatment plant wastes. Metcalf and Eddy has 1 plant in construction, 2 in the design stage, and 1 going into design with waste treatment facilities.

We have been studying treatment plants ranging in size from 100 mgd to 2000 mgd that would operate on a regional basis. Those familar with the problems of the New York City water supply will realize that plants of this magnitude will be required in the next 25 years. Plants of this magnitude will require significant waste treatment facilities.

We have been handicapped by the lack of basic data. The most elemental data, that would necessarily require the development of a standard method to obtain, is the suspended solids. Turbidity has been a common handle for water treatment plant operation. When we talk about wastes, we are talking about solids that we must handle. Most plants keep accurate records on chemical usage, based on coagulant and coagulant aid usage. From the chemicals being used, we are able to determine the amount of precipitates being formed; but it is very difficult to figure out the amount of solids being separated from the raw water. There are more things common in a sewage waste than in a water treatment influent water.

Fortunately, suspended solids data was available for design consideration in our larger plants. In the future most water treatment plants will have waste disposal problems that must be solved. It makes a great difference in solids generation whether the water contains 20 or 50 ppm of suspended solids. The time to collect such data is now, without necessarily waiting to establish a standard method.

The problem in the Northeast is not sediment, but the organics in the source water. The state is promoting more sophisticated analyses since they realize organics and not turbidity is the problem. The determination of amorphous matter and volatile solids would be important considerations. These parameters are reflected in seasonal variations. Analyses should be frequent enough to display seasonal trends for a water treatment system. This is an important design factor.

The reduction of wastes is a most important factor. Preventive action is more effective than taking care of the waste disposal problem once it is created. As mentioned earlier, organics are the major problem in the Northeast. In New York, we are faced with using the 10 States Standards that have been designed to treat Mississippi River water. 90 per cent of the Northeast supply is impounded water, and you can never find a brown color in the Hudson River. There has to be a strong effort, in those parts of the country where sediment is not the problem, to eliminate the use of alum. New York has shown that if you can prove that coagulants are not needed, they will accept a design that does not employ them.

Metcalf and Eddy has adopted 2 waste disposal methods, lagooning and natural freezing, based on economics. A settling lagoon 10 feet deep could hold 5 feet of sludge, and 2 separate freezing lagoons could be provided. The sludge can be spilled or sprayed on the bed. Johnson Well Screen type strainers are being installed in all the lagoons to permit decantation of water. A considerable area is required for waste treatment. The magnitude of the waste facilities is proportional to the size of the plant and will increase directly with the amount of wastes produced.

Plants of 100 mgd or greater will present formidable waste disposal problems. In the Hudson River study, a maximum of 20 ppm of solids was considered and a coagulant dosage of a grain of alum. In this case, a reduction of wastes is the most important factor. The reduction may be either on the preventive or treatment side. For the 100 mgd or greater plants, alum recovery has been determined to be the best method. The limitation of alum recovery is that such a plant requires more sophisticated operators and operations.

A plant of 280 mgd, utilizing alum recovery, was discussed. The waste area facilities have been tremendously reduced. This leaves many plants in the 5 to 100 mgd range that have problems with no economically available solutions. A possible solution for these smaller plants might be the development of a package alum recovery system. The alum recovery, including ultimate disposal, on the 100 mgd plants and greater adds $5 to $7 per million gallons of treatment. The cost of mechanical equipment for lagoons is nominal, but the land cost is great.

Some studies have been made on the type of ice-making equipment that would be available for the artificial freezing operation. Most equipment would be applicable for small plant operation. The package type units would be the most logical choice based on the operating personnel experience level.

The Hackensack Water Company has stored sludge since 1926. The company has not run out of area yet, but they are getting worried. The fill site is similar to sites in Florida where wastes from phosphates or phosphoric acid operations are dumped.

Engineering Needs - P.W. Doe

There are several examples where plant research is needed to provide valuable information. Sludge pumping is one variable that must be considered in sludge handling. The viscosity of the sludge changes with the variation of solids concentration. The standard head loss equation, $h_L = \frac{fL}{D} \frac{V^2}{2g}$, ceases to apply after a certain point. An illustration of the difficulty of handling sludge is evident in this example. Sludge was pumped by Moyno pumps to a tank 30 feet high. The sludge from this tank had to flow through a 120 feet of line to a freezing plant. Polyelectrolytes were used in the sedimentation basins and increased the sludge solids content from about 3 to 5 per cent. The result was that the 25 percent grade on which the pipe was laid was not sufficient for gravity flow. The line had to be broken and another Moyno pump inserted to pump into the freezing tanks.

Handling of low and high concentration sludges also presents problems. Alum sludge, which is thixotropic, will settle in a pipeline when it is pumped at high solids concentrations. Some provision should be made for draining the pipeline while the sludge is fluid to avoid settling during intermittent operation. When the sludge reaches a higher solids concentrations, a different solids handling mechanism, such as a screw conveyor, might be used. If raw sludge or water contacts the cakes, the sludge can revert to its fluid form. The screw conveyor then will grind the cakes back into a slurry. The end product is important. Whatever the solids concentration of the cake, there must be a means of finally disposing it.

Operating data and experience would be greatly appreciated in this area.

The methods of sludge withdrawal from sedimentation basins is an important consideration since it may affect the concentration and quantity of waste. Using Moyno or other pumps to desludge the basins on a continuous or intermittent basis could provide needed data. The goal of withdrawal would be to produce a sludge of minimum volume and maximum concentration.

There may be some other ideas to be examined in final disposal. Can sludge be disposed of in undergroumd aquifers? If the sludge is pumped to gravel beds, the interstices of the gravel bed will fill with sludge and a supernatant will be displaced from the top. Filter press cakes may be disposed of on a sanitary landfill. These cakes generally do not revert, but break down into smaller pieces. The interstices of a sanitary landfill could be filled with this material.

There is little information on the effect of alum sludge on activated sludge, trickling filters, and digestors other than some economics. A research program could investigate the effect of increasing alum sludge in increments from 1 percent to 8 percent, etc in such units. This disposal method would be very cheap and should be investigated.

The use of incineration to further reduce combustible components of sludge should be examined. The level of dryness should be determined to see where combustion is self-supporting. Existing incinerators could be used with increased amounts of pressed cakes to develop data. The incineration of polyelectrolyte sludge could be examined to show advantages and disadvantages of the incineration process.

The long term storage of sludge should be investigated. Personal experience has indicated that sludge will turn purple, undergo anaerobic digestion, and produce methane after a 14 day storage period or thereabouts.

The lagooning of sludges presents problems of maintenance, safety and liability. A quarry should be fenced to prevent access by children who might inadvertently attempt to walk over a seemingly stable sludge crust. A fence will last 10 years but may then require maintenance. In the case of accidents or death resulting from people falling into lagoons, the legal liability is tremendous.

Practical experience on the use of polyelectrolytes should be collected by the Foundation. This information would provide direction and guidance for developers, designers, and operators.

A list of plants that have waste treatment disposal facilities was reported:

1. Stocks plant, Fylde Water Board (England) - freezing
2. Daer Water Board, Scotland - alum recovery and freezing
3. United Kingdom Atomic Energy Commission - Freezing of phosphate sludge.
4. Tokyo - alum recovery
5. Stocks Treatment Plant - 2 filter presses

6. Broughton Treatment Plant - 1 filter press
7. Manchester Corporation Waterworks - 2 filter presses
8. City of Atlanta - 1 filter press
9. Passaic Valley Commission - 2 presses

It may be possible, at selected plants, to make weekly logs of raw water suspended solids, chemical dosages, and sludge produced, so that chemical balance could be attempted.

If the information is not available, small joint ventures might be undertaken to develop needed data. Abstracts from pilot operations could be publicized by the Foundation.

Research instrumentation could be included in engineering design. At the Passaic Valley plant, sludge will be pumped through some 1000 feet. By installing pressure gages and other instrumentation, head loss curves could be developed for sludge at different flows and concentrations. This field of research is easy to do and write up.

Chlorinated rubber base paints provide good protection against corrosion in sludge storage tanks. Epoxy paints, on the other hand, sometimes tend to strip. The report of effective materials for corrosion resistance is another important consideration. PVC pipe is also very resistant to the corrosive nature of alum sludge.

A bibliography of information should be developed for ready reference and as a complete file of sludge disposal literature. The Foundation should have as a complete reference as possible to be a true clearing-house.

Discussion of Engineering Needs

Waste reduction was considered important. Polymers might be used to replace alum. If efficient incineration processes could be developed without producing air pollution, only small residues of non-combustible material would be produced. Only a bare minimum of material would be produced for ultimate disposal.

Alum recovery studies, conducted by the Metropolitan Water District of Southern California, have shown that the higher the ratio of aluminum hydroxide to other materials, the higher the percentage of alum recovery. Tokyo claims to get 80 percent recovery of alum. Small scale studies, both laboratory and pilot plant stages, indicate that it is useless to recover alum on sludges having a 5 percent aluminum content. The Metropolitan Water District studies have shown recoveries of from 80 to 93 percent. When the organic content is increased to 50 percent in the waste, recovery of alum is from 80 to 85 percent.

The Metropolitan Water District has modified the Japanese alum recovery procedure to gain higher efficiency. Instead of decanting the aluminum sulphate solutions and leaving the remainder of the insoluble material, the sludge is treated with acid and passed through a filter press.

This squeezes out the soluble alum and leaves a cake of 50 percent solids with some residual alum. The Japanese attempted to increase recovery efficiency through elutriation, but diluted the recovered solution too much.

Metcalf and Eddy has considered the lagooning and natural freezing of sludge as a treatment method. In the design of a sludge treatment and disposal facility for a 5mgd water utility, several points were raised. The major problem in the northern part of the U.S. is snow. The effect of 18 inches of snow covering partially frozen sludge is unknown. The design provides flexibility by allowing spilling or spraying of the sludge on the bed.

Metcalf and Eddy is considering 60 percent recovery for alum reclaiming operations. The raw water source is the Hudson River, containing a 20ppm maximum solids concentration. The waste sludge will contain a large amount of aluminum hydroxide. In alum recovery, aluminum hydroxide is converted into aluminum sulfate through treatment with sulfuric acid. Some aluminum sulfate must be contained in the final waste. With a low recovery and a pH of 2, the waste must be neutralized with lime. Wastes containing a high percentage of alum, due to poor recovery operation, will form aluminum hydroxide. The recovery method, in this case, is very inefficient and expensive if recovery factors are not reasonable. A 1 to 2 percent solution of recovered liquid alum would be good.

Metcalf and Eddy has also done studies of vacuum filtration of water sludges with sewage sludges. Adding extra lime to the mixture improved the filtration. This operation is not suitable when sludge transmission is required. If the sludge is discharged to sewers, digestor capacity would have to be increased, creating economic problems.

The applicability of nuclear sludge density meters for the control of water treatment sludges, similar to the meters used for the control of sewage sludge, was considered. This unit may provide means to operate at an optimum sludge density at all times. These meters eliminate the need for starting a pump to sample the sludge density. Sewage treatment plants sometimes use these meters for primary sludge density control. The unit is a continuous metering device mounted in-line. The meter is produced by Industrial Nucleonics of Columbus, Ohio.

The utility of this meter for controlling alum or softening sludges is unknown. Sewage sludge solids have a different density than alum sludge. Densities of alum sludge and water are so close that a high solids concentration is required to give a measureable difference.

The Metropolitan Water District of Southern California is using a nuclear sludge density meter at a washwater reclamation facility treating filter backwash water. The meter appears to be an effective measuring device in the 4 to 5 percent density range. The meter results have been correlated with laboratory tests.

The availability of equipment to treat sludge from water treatment plants should be explored. The cooperation of manufacturers in providing information on other products would help water utilities and designers in building pilot and plant scale sludge treatment systems.

Regulatory Needs - R. Boes, R. Evans

The need was pointed out for a questionnaire that would establish a clear "picture of what is being done and what must be done in the future", regarding waste discharges from water treatment plants as viewed by regulatory agencies.

A review was made of the responses to a previous questionnaire (1968) included in the Foundation's first report concerning Regulatory Aspects. Although a large majority of regulatory agencies considered wastes from water treatment plants a definite source of pollution, and had established regulations governing discharges, only 5 of 53 responding "had data on the characteristics and quantities of these wastes. This is not unusual since regulatory agencies generally are not involved in conducting or supporting research at least at the state level.

It seemed pertinent to find out what these agencies consider major sources of pollution from water treatment processes as well as their views upon acceptable treatment, particularly since decisions are being made in spite of the lack of basic data and research findings. There is need for a new questionnaire that would define some areas, for the Foundation's study, as well as provide some insight on the regulatory agencies activities regarding treatment requirements and fundings.

Discussion of Regulatory Needs

Relating to the 1953 survey by Dean and to the 1968 survey by the Research Foundation, a marked change is evident in regulatory agency attitudes. The policy in most states is that new water treatment plants will require waste handling facilities. The 1968 survey replies that existing plants will not be required to develop waste handling facilities unless their waste discharges cause definite problems. If an existing plant is modified or expanded, appropriate waste handling facilities will be required. Pressure may require even existing plants to treat wastes.

The most evident problem is visible wastes. In Cincinnati, the filter backwash water contains considerable carbon that is visible when it is discharged to the Miami River. This causes complaints. If the same waste was discharged to the Ohio River through a diffuser, it would not be visible. Aesthetic problems caused by visible wastes arouse the public.

In Illinois, the Division of Water Treatment acts as a breaking force between water utilities and the Bureau of Stream Pollution. This Division is most cognizant of the water treatment waste disposal problem. Good cooperation exists between water utility superintendents and regulatory agencies. These agencies can provide good advice to the stream pollution personnel.

Regulatory agencies adopt increasing controls on water utilities when complaints of visible wastes are reported. The Columbus, Ohio,water treatment plant has been a softening facility since 1910. Softening sludge was discharged from this plant to the river below a dam. The spring floods washed the sludge away. Complaints were received for 60 years. In the last 4 or 5 years so much pressure was applied that this disposal method was eliminated. A commercial lime plant, supplying this facility, was located next to the plant. It had several large holes that could serve as permanent lagoons. The lime company studied the reprocessing of the lime sludge from the water treatment plant by burning, and found that it was possible to develop a high purity lime. The costs for hauling and thickening lime sludges and competition from a nearby lime supplier outweighed the market potential of the proposed recalcination process.

For waste disposal requirements, some states use effluent standards and others use treatment standards based on stream quality criteria. States using the stream quality criteria generally contain clauses in their permits specifying what must be done to meet treatment requirements in 6 to 12 month periods. The permit amounts to being an effluent standard although it is not classified as such officially. The states not using effluent standards inform designers engaged in water treatment and sewage treatment plant work of their criteria, so that designers work in terms of effluent waste standards.

It was suggested that effluent standards are established to facilitate the administration of water pollution abatement measures. Some regulatory agencies may have knowledge of the assimilative capacity of the stream. With this knowledge, criteria may be provided for a waste treatment setting waste effluent levels at 80 ppm suspended solids at a certain mile point on a river. For instance, at critical flows in the Cincinnati River, 15 tons of material are required to change the river concentration of this material 1 mg/l. The use of the assimilative capacity of rivers and streams in many cases would require complex analses.

SECTION VI

TECHNOLOGY TRANSFER RESULTS

Introduction

The AWWA Research Foundation, as a central information resource, identifies and inventories research and demonstration studies dealing with the treatment and disposal of wastes from water treatment plants. Several sources have been searched to determine the type, extent, and status of research activities both in the United States and several foreign research organizations.

In its first year of operation as an information clearinghouse, the Research Foundation has collected and organized information on research and demonstration studies from a variety of sources. These sources include: Science Information Exchange of the Smithsonian Institution; Water Quality Office of the Environmental Protection Agency; Office of Saline Water, U.S. Department of the Interior; personal correspondence with principal research investigators; members of the Fylde Water Board, Blackpool, Lancashire, England; and reports discovered through literature searches. Several new research reports have been published since the publication of the first AWWA Research Foundation report titled "Disposal of Wastes from Water Treatment Plants."

The material following represents the research activity identified for the treatment and disposal of wastes from both conventional and desalting water treatment facilities. This information defines new or modified waste treatment technology. Accumulated information is classified and stored in the Research Foundation's Research & Development Information Storage and Retrieval System.

News of research activity is valuable to the water utility industry. The Research Foundation plans to continue and expand the organization, coordination and dissemination of information on the waste disposal problem. Additional research and demonstration projects dealing with this subject area, submitted to or discovered by the Research Foundation will be reviewed and incorporated into this expanding study.

Science Information Exchange

The mission of the Science Information Exchange (SIE) is described as: "to facilitate effective planning and management of scientific research activities supported by the U.S. agencies and non-Federal institutions...."

The Research Foundation utilized the services of this organization to define research activity for the subject area titled "treatment and disposal of sludge from water treatment plants-all types of water treatment plants including desalination plants."

The SIE was able to provide copies of Notices of Research Projects that

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they have received from Federal and state department agencies, educational institutions, and various commercial organizations. These Notices are provided with the understanding that they may not be utilized for publication or publication reference without the permission of the principal investigators involved.

The Research Foundation contacted those investigators having information on treatment technology applicable for the control of pollution caused by wastes from water treatment plants. The researchers were informed of the Foundation's principal activities, the collection and exchange of data on laboratory, pilot plant, and full scale studies.

Each investigator was asked to permit the Research Foundation to include the Notice of Research Project in its Research & Development Information Storage & Retrieval System, and to inform the Research Foundation of the availability of reports describing progress in the study.

The following summary reports illustrate studies conducted by individuals or organizations that have granted permission to the Foundation to include their work in the information resource.

These Notices of Research Projects are listed alphabetically by the supporting agency for each study. These agencies are the Business and Defense Services Administration; City Government of Decatur, Illinois; Federal Water Quality Administration; Office of Saline Water; Office of Water Resources Research; State Government of Illinois; and the University of Illinois.

Supporting Agency: Commerce Department, Business & Def. Services Adm.

Title of Project: Production of Water and Waste Water Treatment Equipment (1968)

Principal Investigators: K.L. Kollar and W.G. Youngwirth

Recipient Institution: U.S. Department of Commerce, Bus.&Defense Ser. Admin., Washington, D.C.

Summary of Project: Water Quality Management and Protection: A survey has been completed of some 180 manufacturing establishments engaged in the production of water and wastewater treatment equipment. The number and value of treatment equipment produced in 1968 and the production capacity for 24 major product categories will be published in a report 9/1970. Among the products the report will cover are chemical feed equipment, filtration equipment, sludge digestion and disposal equipment and package treatment plants.

Supporting Agency: Decatur City Government - Illinois

Title of Project: Thickening and Dewatering of Water Treatment Sludge

Principal Investigators: R.I. Dick and J.I. Barkman

Recipient Institution: Univ. of Illinois, School of Engineering, Urbana, Illinois

Summary of Project: Laboratory and full scale plant investigations are being conducted to develop operational parameters for a gravity thickener to yield optimum volume reduction and solids concentration. Further dewatering investigations have involved the use of various polyelectrolytes to improve the filterability of the softening-clarification sludge by an existing vacuum coilfilter.

Supporting Agency: Interior Department, Federal Water Quality Administration

Title of Project: Lime Sludge Recovery and Reuse

Principal Investigators: M.C. Mulbarger and R.B. Dean

Recipient Institution: U.S. Dept. of the Interior, Federal Water Quality, Admin, Cincinnati, Ohio

Summary of Project: Lime in doses of 200 to 500 mg/l as $Ca(OH)_2$ removes phosphates and suspended matter from secondary effluents. The resultant sludge consists of calcium carbonates and phosphates together with silicate minerals, magnesium hydroxide and organic matter. Although the recovered lime may cost nearly as much as fresh lime, the problem of disposing of large volumes of sludge is solved. Waters differing in hardness and phosphate content have been treated through four cycles and the quantity and quality of the recovered lime has been measured. In soft waters calcium phosphate builds up until it represents over half of the weight of calcined lime without exerting any deleterious effect, provided that fresh lime is added to make up the losses. In hard waters calcium carbonate is removed from the water and must be continuously wasted along with low concentrations of calcium phosphate.

Supporting Agency: Interior Department, Federal Water Quality Admin.

Title of Project: The Thickening and Dewatering of Precipitates from the Lime/Limestone Treatment of Mine Drainage

Principal Investigator: Edward Moss

Recipient Institution: West Va. University, School of Mines, Morgantown, West Virginia

Summary of Project: The proposed work will consist of a detailed studyof the problem of densification of ferric hydroxide -- calcium sulphate sludges which result from the lime or limestone treatment and aeration of acid waters from coal mines. The project will focus on the interrelationship of mine water chemistry with the settleability of sludges and possible methods used to chemically or mechanically concentrate and dewater these sludges. Areas of study will include filtering, flocculation, decantation, centrifuging, thickening, and cycloning. A "State of the Art" review of potentially useful existing dewatering methods as they apply to mine water treatment sludges will be completed early in the study. The economics of alternative treatment schemes will be examined with the objective of reducing the overall costs of water treatment and sludge disposal. The project will begin in February, 1972.

Supporting Agency: Interior Department, Federal Water Quality Admin. & Common. of Pa.

Title of Project: Neutralization and Precoat Filtration of Concentration Sludges from Mine Water

Principal Investigator: Dr. D.R. Maneval

Recipient Institution: State Dept. of Mines & Min., Harrisburg, Pa.

Summary of Project: The project is directed at providing a cost-effectiveness evaluation of various neutralization processes in the treatment of acid mine drainage. Sludge disposal problems will be studied with emphasis on precoat filtration. Field test will be accomplished on four abandoned mines in the Western Pennsylvania area. Johns-Manville Company will perform the work. It is hoped that this method will provide significant information on economic feasibility of reducing acid mine drainage by neutralization.

Supporting Agency: Interior Department, Federal Water Quality Admin.

Title of Project: Treatment of Acid Rinse Waters

Principal Investigator: J. Barker

Recipient Institution: Armco Steel Corporation Middletown, Ohio

Summary of Project: The project provides for construction, operation, tests, and reports on facilities to treat 1500 gpm of acid rinse waters produced by the hydrochloric acid pickling of strip-steel preparatory to cold-rolling. The treatment process will consist of limestone neutralization, aeration, coagulation, sedimentation, sludge recirculation, vacuum filtration of the excess sludge, and effluent equalization. All or nearly all of the acid and the compounds of iron will be removed by the treatment process. The chloride content of the waste is not changed by this process and may be such that dilution with other available wastes will be required in order to meet the state's proposed standards regarding total dissolved solids.

Supporting Agency: Interior Department, Office of Saline

Title of Project: The Feasibility of Obtaining a Solid (Dry) Brine Effluent from Desalting Plants at Inland Locations

Principal Investigators: W.F. McIlhenny, B.P. Shepherd, P.G. Legros, and J.C. Williams

Recipient Institution: Dow Chemical Company, Midland, Michigan

Summary of Project: In the first phase of this project a survey will be performed of the chemical and process industries to determine applicable methods of reducing or removing solids from solutions. The constituents of brackish water will be determined and the potential usefulness of the processes for treating of the brine effluents from desalination plants will be determined. Secondly, the economic feaseabilities and potential size limitations of each alternation will be determined and the advantage, disadvantage, and economic potentials of the alternatives will be compared. Processes which, at this time, appear to merit for treating and desalting brines to produce dry solids include: (1) Solvent extraction; (2) Fluid-bed drying; (3) Spray calcination.

Supporting Agency: Interior Department, Office of Saline Water

Title of Project: Determining the Feasibility of Obtaining Dry Brine Effluents from Desalting Plants at Inland Locations

Principal Investigators: I. Yen, D. Garrett, E.A. Manker, M.J. Kallerud, and E. Chemtoe

Recipient Institution: Garrett Res. & Dev. Co. Inc., La Verne, California

Summary of Project: This project will prepare a conceptual design of a desalination plant using solar ponds in conjunction with a multistage flash evaporator. The solar ponds shall be used not only for evaporation but also as solar energy collectors to heat the feed brine for further processing. The complete plant shall be designed for a total potable water output of 2.5mgd. Plant scaling factors shall be provided for 1 to 10mgd plants. The conceptual design shall include process flowsheet, heat and material balance, equipment layouts, materials of construction, design calculations and elevation or sectional drawings required to fully describe the designed plant and/or principal items of equipment capital and operating cost estimates shall be prepared for the designed plant and related to the cost of fresh water output so that a cost of reduction or removal of solids can be determined for a fresh water output.

Supporting Agency: Interior Department, Office of Saline Water

Title of Project: Feasibility of Obtaining a Solid (Dry) Brine Effluent from Desalting Plants at Inland Locations

Principal Investigators: R.W. Fosterpegg, G.W. Blair, S.A. Laurich, N. Ganiaris, R.H. Hedrick, and R.J. Glasser

Recipient Institution: Struthers Energy Systems Inc., Warren, Pennsylvania

Summary of Project: This project will investigate the recovery and use of solids from the brine effluent from a 2.5 mgd desalting plant. Processes to be examined are: 1. The use of a single and multiple effect crystallyzer/evaporators for removing or reducing the solids from solution; 2. The operating parameters of a crystallizer to determine the economic feasibility of designing for production of salts with a commercial value; 3. The use of a direct contact spray type granulator and/or fluidized bed dryer for final effluent drying. The above processes will be compared as to advantages, disadvantages, and economic potential, and potential size limitations will be determined. For the most optimum of these processes a conceptual design will be prepared for a plant treating the effluent of a 2.5mgd desalination plant. The capital and operating cost estimates for this plant will be determined so that the cost of reduction or removal of solids can be determined for a unit of fresh water output.

Supporting Agency: Interior Department, Office of Saline Water

Title of Project: Recovery of Chemicals as a Means of Brine Disposal

Principal Investigators: E. Rabin, C.J. Avery, and P. Hadzeriga

Recipient Institution: Environmental Qual. Eng. Inc., Oakland, California

Summary of Project: Candidate products, processes, and sites will be identified for the recovery of chemicals from desalting plant effluents. Associated economic and process design data will be assembled, and environmental problems will be examined. Feasability criteria for the potential of the process will be established. Based on this information and criteria, block flow diagrams will be developed for approximately eight products and sixteen processes. A preliminary market analysis will be performed on each product under consideration. The interrelation between chemical and desalting plants will be evaluated to include such factors as descaling, effluent brine concentration & composition, and changes in residual waste disposal resulting from chemical recovery. Based on these exploratory studies, the most promising products, processes and sites will be selected for a preliminary engineering and economic analysis. This will include determination of the smallest plant size that will support chemical recovery. The results of this analysis will be used to (1) identify the most promising integrated facility for desalting-chemical recovery, and (2) determine research efforts necessary for advancement of chemical recovery methods for brine disposal.

Supporting Agency: Interior Department, Office of Saline Water

Title of Project: Disposal of Brine Effluents by Conversion to By-Products

Principal Investigators: R.R. Grinstead and G.E. Fleig

Recipient Institution: Dow Chemical Company, Walnut Creek, California

Summary of Project: This project will examine the application of solvent extraction methods to the separation and concentration of desalination brines to produce products which can be disposed of in normal industrial channels. Such products will include sodium chloride, sodium carbonate, magnesium and calcium carbonates, sodium and ammonium sulphates, and chlorine and caustic soda (from electrolysis of sodium chloride brine). A dual extraction system will be studied, and will be analogous to the Desal ion exchange process for desalinating brackish water. The initial step would be based on the use of amine systems to convert anionic constituents of the brine to bicarbonates, and the second step will utilize acidic extractions to acidify the bicarbonates to carbon dioxide. Among the by-products will be sodium carbonate, which can be used to remove divalent cations from the brine feed or from the original brackish water, ahead of the desalination step. In the latter case, the softened feed water would allow a greater recovery of water in the desalination step. The rationale of using extraction methods in this application rests on the ability of extraction processes to treat and produce stronger salt solutions than ion exchange of methods, since problems of dilution due to mixing of aqueous phases are eliminated.

Supporting Agency: Interior Department, Office of Saline Water

Title of Project: Determining the Feasibility of Alternative Approaches of Obtaining a Solid Dry Brine Effluent from Desalination Plants at Inland Locations

Principal Investigators: S. Lemezis, D.B. Boies, R.L. Coit, V.S. Ivins, and C.J. Bowden

Recipient Institution: Westinghouse Electric Corp., Philadelphia, Pennsylvania

Summary of Project: This project will prepare a conceptual design of a unique multistage flash evaporator concentration system which can receive brine effluent waste from desalting plants of any process and reduce the waste volume to less than ¼ of 1%. The concentration system design capacity shall be based on treating the brine effluent from a 2.5 mgd distillation plant. Plant scaling factors shall be provided for 1 to 10 mgd plants. Capital and operating cost estimates for the 2.5 mgd plant shall be prepared so that the cost of reduction or removal of solids can be determined for a fresh water output. Screening runs on available equipment shall be performed to evaluate water characteristics for design purposes.

Supporting Agency: Interior Department, Office of Saline Water

Title of Project: Study of Approaches of Obtaining Solid Brine Effluents from Desalination Plants

Principal Investigator: F.C. Standiford

Recipient Institution: W.L. Badger & Associates, Ann Arbor, Michigan

Summary of Project: In the first phase of this project, a survey will be performed of the chemical and process industries to determine potential processes for removing or reducing solids from solution when treating the brine effluent from desalination plants. Secondly, the economic feasibility of each alternative will be determined and a cost of reduction or removal of solids will be determined for a unit of fresh water and for the plant sizes under consideration. The potential size limitations of each alternative will be determined and the advantages, and disadvantages and economic potential of these alternatives will be compared. A conceptual design will be prepared for a plant treating the effluent of a 2.5 mgd desalination plant and capital and operating costs for this plant will also be prepared. These costs will be used to determine a cost of reduction or removal of solids for a fresh water output.

Supporting Agency: Interior Department, Office of Saline Water

Title of Project: Evaluation of Soil Sealants from Solar Evaporation Ponds

Principal Investigator: L. Ellsperman

Recipient Institution: U.S. Dept. of the Interior, Bureau of Reclamation, Denver, Colorado

Summary of Project: The Bureau of Reclamation has been conducting studies on surface facilities for the disposal of brine from inland desalting plants. Nine different linings and a control, including two chemical sealants, have been evaluated at Dalpra Farms, Longmont, Colorado. These materials were installed as the base under 18-foot diameter metal tanks. Seepage rates have been determined using brine effluent up to a 5 - foot depth. At the present time the most economical and effective sealants for solar ponds are polyethylene and polyvinyl chloride (PVC) films. However, film materials are subject to mechanical damage which is difficult to repair. Chemical sealants are self-sealing. As a result of the previous laboratory work two new chemical sealants were shown to have a better potential for sealing ponds effectively and at lower cost than most of the materials field tested to date. They are Dow Chemical Company's Sealant No. 1193 and Union Carbide Company's product, DCA-70. The purpose of this project is to field evaluate these two new chemical sealants.

Supporting Agency: Interior Department, Office of Saline Water

Title of Project: Surface Facilities for Disposal of Desalting Plant Effluents

Principal Investigator: L.M. Ellsperman

Recipient Institution: U.S. Dept. of the Interior, Bur. of Reclamation, Denver, Colorado

Summary of Project: Objectives: To develop design criteria for surface facilities to be used in the disposal of desalting plant effluents. Description of Work: a. Perform "state of the art" bibliography, including literature and industry survey. b. Explore and evaluate soil samples from probable sites. c. Conduct a laboratory evaluation of the effectiveness of soil sealants and other lining materials with various brine effluents. d. Develop a monitoring system for continuous and routine measurements of seepage losses. f. Field test soil sealants and other lining materials and develop optimum methods of application. g. Prepare a manual on surface facilities for disposal of desalting plant effluents. h. Conduct an economic study of salt disposal.

Supporting Agency: Interior Department, Office of Water Resources Res.

Title of Project: Conservation of Fresh-Water Resources by Deep-Well Disposal of Liquid Wastes

Principal Investigators: Dr. D.M. Grubes, C.D. Haynes, and W.E. Tucker

Recipient Institution: Univ. of Alabama, Water Resource Program, University, Alabama

Summary of Project: This project will evaluate the geological and engineering parameters of subsurface rock formations which will permit disposal of liquid waste by deep-well injection procedures. Criteria and techniques will be sought which will have both quantitative and qualitative regional application in the development of underground disposal facilities. This will in turn alleviate the problem of usage of surface waters as carriers of waste effluent. Studies will be focused upon: 1. Derivation and analysis of information such as rock core and cuttings lithology, analysis of reservoir fluids, results of rock matrix and cementing material, electrical and other well-logging parameters, and petrophysical data such as porosity and permeability; 2. Laboratory analysis from simulated injection of wastes into actual reservoir core samples to determine capacity, receptivity, continuity and compatibility, and pressure-time-distance response as a basis for prediction or systems behavior; 3. Development of mathematical models applicable to the identification and evaluation of potentially receptive disposal zones. Determination of restrictions to be placed upon types and volumes of liquid wastes which may be injected into specific deep-well reservoirs.

Supporting Agency: Interior Department, Office of Water Resources Res.

Title of Project: Ground Water Contamination Resulting from Waste Disposal

Principal Investigators: J.R. Anderson and J.N. Dornbush

Recipient Institution: South Dakota State University, School of Engineering, Brookings, South Dakota

Summary of Project: Representative waste disposal methods in South Dakota including land disposal of liquid and solid wastes will be investigated to determine: 1. A recommended procedure for selection of waste disposal sites in order to minimize ground water contamination problems. 2. The effects of waste disposal practices including: a. The nature and extent of ground water contamination. b. The effect of ground water contamination on proposed beneficial uses. c. The influence of such factors as climatic conditions, soil types and waste characteristics on the degree and extent of travel of pollutants. 3. A means of combatting undesirable contamination of the ground water. It is also proposed that the project will investigate the long term effects of solid waste landfill on ground water quality in an area where adequate background data have been collected to observe the initial influence.

Supporting Agency: Interior Department, Office of Water Resources Res.

Title of Project: Use of Lime-Soda Ash Sludge for the Treatment of Municipal Wastewater

Principal Investigator: W.J. O'Brien

Recipient Institution: Univ. of Kansas, School of Engineering, Lawrence, Kansas

Summary of Project: The objectives of this reasearch are to analyze the excess sludge produced by the lime-soda ash water softening process used in the municipal water treatment plant at Lawrence, Kansas, and to determine the effectiveness of this material as a precipitant for wastewater. The water softening sludge will be added to the primary sedimentation basin on the municipal wastewater treatment plant to determine the level of phosphate and suspended solids removal that can be obtained at a pH of 9.5 in the sedimentation basin. Final disposal methods for the mixture of biodegradable organic matter and chemical sludge produced at the wastewater treatment plant will also be investigated. Both laboratory and plant scale tests will be conducted. An economic evaluation of the process will also be prepared.

Supporting Agency: Interior Department, Office of Water Resources Res.

Title of Project: Economic Disposal of Waste Sludges from Water Treatment Plants

Principal Investigator: P.H. King

Recipient Institution: Virginia Polytechnic Institute, School of Engineering, Blacksburg, Virginia

Summary of Project: The disposal of sludges resulting from conventional water treatment processes such as coagulation, softening and filtration will be examined with a view of developing alternatives to disposal by dilution in cases where water quality stream standards would be violated or in situations where disposal to lagoons would not be feasible due to land costs. Particular attention will be given to the parameters of treatment plant operation and to sludge conditioning techniques which result in rapid and thorough sludge dewatering on either open sand drying beds or through use of vacuum filters. The use of newly developed synthetic organic polyelectrolytes as a conditioning aid will be investigated. The economics of alternative methods of water treatment plant sludge disposal under varying conditions will be evaluated.

Supporting Agency: Interior Department, Office of Water Resources Res.

Title of Project: Effect of Environmental Factors on Design and Operation of Open-Air Sludge Drying Beds

Principal Investigator: Dr. J.C. Jennett

Recipient Institution: Univ. of Missouri, School of Engineering, Rolla, Missouri

Summary of Project: In order to develop rational techniques for the design of open-air sludge drying beds, it is necessary to understand the effect environment has on the process. The main approach of this investigation is to study the fundamental aspects of sludge drying and how environment is a factor. The specific objectives of this project are to develop laboratory procedures which will allow the quantitative evaluation of the effects of environment on sludge drying; to evaluate the experimental results gained from the laboratory to determine how and to what degree environment and sludge bed design affect the rate and extent of sludge drying; and to develop a rational approach to the design and operation of these drying beds. Laboratory investigations will be performed using model sludge drying beds in environmental chambers which allow the control of the physical environment so that each variable may be held constant or changed as desired. Laboratory and field data will be correlated to allow practical application of the results.

Supporting Agency: Interior Department, Office of Water Resources Res.

Title of Project: Treatment of Water-Plant Sludges

Principal Investigator: Dr. J.F. Judkins

Recipient Insitutions: Auburn University, School of Engineering, Auburn, Alabama

Summary of Project: The objectives of the proposed research are to investigate the crystal seeding process as a means of improving the filterability of water treatment plant sludge. The process will be investigated for its applicability to both coagulant sludges and lime-softening sludges. Variables of interest will include crystal seed dosage, mixing rate and the concentrations of impurities in the water. Studies will be conducted on laboratory samples prepared by the addition of typical concentrations of turbidity, hardness and alkalinity to distilled water.

Supporting Agency: Illinois State Government

Title of Project: Water Treatment Plant Wastes

Principal Investigation: R.L. Evans

Recipient Institution: State Water Survey, Urbana, Illinois

Summary of Project: A study is under way to determine the effect, if any, that waste generated by water treatment plants may have on potential or existing water supply sources, as well as other legitimate users of water. An effort has been made on a statewide basis to determine 1) existing methods of water treatment wastes disposal; 2) types and quantities of waste generated per unit quantity of water treated; and 3) chemical, physical, and biological characteristics of the wastes. That phase of the project involving classification units and water softening is complete. Current efforts are devoted to investigating municipal ion exchange units involving principally brine wastes.

Supporting Agency: University of Illinois

Title of Project: Gravity Thickening Theory

Principal Investigators: R.I. Dick and B. Shin

Recipient Institution: University of Illinois, School of Engineering, Urbana, Illinois

Summary of Project: Kynch's theory is being used as a basis for study of the gravity thickening behavior of suspensions. Extensions and modifications of the theory as suggested by reported performance of gravity and continuous thickeners are being developed.

Plant Visits

The Research Foundation staff visited two water utilities conducting pilot and plant scale activities. The Hackensack Water Company of Oradell, New Jersey, is using pilot plant units to determine the effect of recycling and reusing filter washwater. The City of Atlanta, Georgia, is installing two pressure filters to dewater the sludge from the Chattahoochee Water Treatment Plant.

Hackensack Water Company

The Hackensack Water Company is conducting an in-house study on the "Recycling and the Reuse of Filter Washwater." The water utility is funding and staffing this project.

The one gallon per minute pilot plant includes flocculation, sedimentation, and filtration units; it is supplied with water drawn from the influent basin of the main treatment plant. This water contains the normal chemical dosages of chlorine, alum and carbon; to it, in the flash mixer of the pilot plant, filter backwash water is added. The backwash water represents 2 to 3 percent of the composite one gallon per minute flow processed.

The initial source of backwash wastewater was a composite sample of washwater from one of the full scale plant filters. In continuing pilot plant operation, filter washwater from the pilot filters was recycled and reused.

Following rapid mixing and settling, the clarified effluent is fed to a multi-media pilot filtration unit.

The experimental filters are composed of 42 inches of anthracite, with gravel bottoms. The surface area is 0.233 sq. feet and the flow through the filters is 4.5 gpm per sq. ft. The filters are washed every 30 hours at 32 inches rise per minute for 8 minutes, corresponding to the use and backwashing schedule of the actual full scale plant filters.

Samples of the pilot plant basin and filter effluents are collected for analysis. Head loss readings are recorded both for control and experimental filters.

The effectiveness and economy of chemically coagulating a filter washwater will be evaluated. It is proposed that this process will reclaim the liquid portion of the washwater and eliminate the need for separate washwater sedimentation basins to settle potential solid pollutants.

Atlanta, Georgia

The City of Atlanta is installing Beloit-Passavant sludge dewatering equipment to dewater the alum sludge generated at the Chattahoochee Water Treatment Plant. The selection of this equipment followed extensive testing in which air flotation, vacuum filtration, centrifugation, and filter pressing processes were evaluated. It is anticipated that Atlanta will be the first United States city to dewater alum sludge by filter pressing on a plant scale basis. The addition of seven new dual media filters will increase the plant design capacity to 60 mgd.

The full scale waste dewatering plant will consist of two series 6400 Beloit-Passavant Pressure Filters. The presses are expected to produce a filter cake with a solids concentration between 40 and 45 percent. The alum sludge will be conditioned with lime before processing. The filter cake can be disposed of as a landfill. The capacity of the two pressure filters being installed is approximately 55,000 pounds of dry solids daily. It is expected that the Chattahoochee Sludge Dewatering Plant will go into service in late 1971.

Manufacturer Research

The Permutit Research and Development Center has reported initiating pilot plant studies on the dewatering of alum, ferric hydroxide, and calcium carbonate sludges. The Center is preparing a paper titled "Dewatering of Water Plant Sludges." An abstract of this paper, submitted to the Research Foundation, states:

"A method of gravity dewatering of typical water plant sludges is presented. The sludges studied include aluminum hydroxide, iron hydroxide, magnesium hydroxide, and calcium carbonate. Due to their greater complexity, water plant sludges are more difficult to dewater than a pure aluminum hydroxide or a pure ferric hydroxide sludge. Water plant sludges are fragile under stress and of particle sizes unsuitable for rapid dewatering. The new gravity dewatering treatment system judiciously utilizes; (1) polymers which produce a floc having the proper particle size and integrity for gravity dewatering, and (2) a moving bed gravity dewatering device that maintains an extremely thin cake in its gravity dewatering compartment."

Water Quality Office, E.P.A.

There have been two studies identified through the Water Quality Office of the Environmental Protection Agency.

The first study is titled "Treatment of Waste Alum Sludge." A grant of $31,871 was awarded to the City of Albany, New York, Department of Water and Water Supply. The project is expected to run from June, 1971 to December, 1971.

The purpose of this study is "to conduct a detailed pilot plant alum sludge filtration study at the Feura Bush Water Treatment Plant of the City of Albany. The objectives are to optimize operating parameters, demonstrate process reproducibility, and develop information necessary for full-scale plant design.

The technical and economic feasibility of rotary vacuum precoat filtration of alum sludge will be evaluated. A comparison will be made of the performance of various types and grades of filter aids, and other operating variables. Design and criteria for a full-scale facility will be sought.

The second study is jointly funded by the Water Quality Office of the E.P.A.; The City of Montgomery, Alabama; and the AWWA Research Foundation. The project is titled "Use and Recovery of Magnesium Carbonate for Color & Turbidity Removal from Municipal Water."

The purpose of this study is to evaluate the effectiveness of magnesium carbonate as a recycled coagulant for use in removing color and turbidity from raw water sources at municipal purification plants. Magnesium carbonate is presently reclaimed at the Dayton, Ohio, water softening plant from a sludge containing calcium carbonate and magnesium hydroxide. The calcium carbonate sludge is recalcined to recover lime for plant operation and excess lime is sold.

In the conversion of magnesium hydroxide to magnesium carbonate, sludge from the softening facility is carbonated, using carbon dioxide produced from the rotary kiln of the lime recovery furnace. The carbon dioxide selectively converts the insoluble magnesium hydroxide to a soluble carbonate. A physical solid - liquid separation process allows the recovery of a magnesium carbonate supernatent solution before the calcium carbonate sludge is calcined. The use of magnesium carbonate as an alum coagulant replacement represents a new technology in water treatment that will alter the character of waste sludges.

Pilot and plant scale testing of this coagulant at the Montgomery, Alabama, water treatment plant will determine operating and design variables for the new process. The recycling of magnesium carbonate coagulant in purification plants will alleviate the magnitude of wastes for ultimate disposal at these facilities.

Correspondence - Domestic

Three studies on the treatment of settling basin sludge and filter washwater have been reported to the Research Foundation for incorporation into this information resource. These studies deal with the centrifugation, lagooning, and recycling of waste sludges.

The first study is titled "Treatment and Disposal of Sedimentation Tank Sludge and Sand Filter Backwash Water, Van Bibber Treatment Plant, Edgewood Arsenal, Maryland."

The engineering firm of Van Reuth and Weidner, Inc. was contracted by the Baltimore District, Corps of Engineers, Department of the Army, to study and report on the treatment and disposal of sedimentation tank sludge and sand filter backwash water from the Van Bibber Water Treatment Plant at Edgewood Arsenal, Maryland. The study was undertaken for the purpose of meeting more stringent state pollution abatement laws governing the discharge of wastes from water treatment plants.

Several treatment processes were evaluated for concentrating the predominantly aluminum hydroxide sludge at this purification plant with a design capacity of 4.0 mgd. Laboratory tests were conducted on potential dewatering methods including vacuum filtration, sand filtration, evaporation and decanting (lagooning), freezing, chemical treatment, and centrifugation. Evaporative lagooning with decantation and centrifugation with chemical treatment were found to warrant further investigation in this application due to their practicality and efficiency.

Field demonstration tests on waste conditioned with synthetic organic polymers were made using a Dorr-Oliver Merco Bowl Centrifuge. Tests showed that at this plant, centrifugation was the most economical treatment process for the handling of the sludge and filter backwash water.

The recommendations from the study have been adopted and now constitute the basis for design and construction of new facilities which are scheduled for early completion at the Van Bibber Plant. The construction costs are estimated at $180,000 and annual operating and maintenance costs are estimated at $29,000. This report is the result of investigations conducted by the authors for the U.S. Army Engineer District, Baltimore, and is released pursuant to current policy, as a matter of possible interest to the engineering profession.

The second study reported is an engineering proposal made for the settling of filter washwater from a water treatment facility. The supernatant from the settling process will be reclaimed.

Reagan & Mc Caughan, Consultant Engineers from Corpus Christi, Texas, have proposed waste treatment facilities to control the pollution caused by sedimentation tank sludge and filter backwash water at a Nueces County Water Control & Improvement District No. 3 water treatment plant. This utility provides 1.5 mgd of domestic water for the City of Robstown and the surrounding area.

Lime, alum, and chlorine are used to treat the raw water at this plant. The source water is pumped from the Nueces River into an earthen canal and then flows into a series of lakes at the treatment plant site. The wastewater from the coagulation and filter washing process is presently discharged to a drainage ditch owned and operated by a Drainage District. The Texas Water Quality Board has noted objections to this procedure and has advised the District to find a new disposal technique.

The consultants have proposed that the sludge and filter washwater be treated in earth settling basins. The clarified effluent would then be returned to the raw water lake. Two basins would be provided to allow operation of one and cleaning of the other. The sludge from these basins would be ultimately disposed of at a suitable site. The settled sludge may have utility as a fertilizer for grain or cotton crops.

A third study has been reported by the superintendent of the water works for the City of Cincinnati, Ohio.

"Plans are being formulated to recycle spent washwater, with raw incoming water, through the primary sedimentation basins. The installations will provide for two methods of initial experimentation:

1. Recycling of spent washwater with sludge from secondary treatment.

2. Recycling of spent washwater alone.

Experiments are now underway to concentrate secondary treatment plant sludge in lagoons. In these, it is anticipated that some concentration will occur due to perculation, evaporation and natural winter freezing.

The residual will be pumped in thin layers on farm land, harrowed in, fertilized, and otherwise treated to form an acceptable base on which to grow sod. The end result being a sod farm (to supply City Departments) with a self-perpetuating top soil. Water is to be decanted from the lagoons using a valved tower to regulate the effluent level being decanted. "

Correspondence - Foreign

Several foreign research organizations have been contacted to determine the type and status of activity involving the treatment of water utility wastes.

The Fylde Water Board provided three reports that were not referenced in the Foundation's 1969 report on the disposal of wastes from water treatment plants. These reports have been abstracted by the Research Foundation and transmitted to the Water Resources Science Information Center. The abstracts follow.

Benn, D. and Bridge, L., "Sludge Disposal by Pressing," Paper of Fylde Water Board, Blackpool, Lancashire, England.

Key Words: Design data, Filter pressing, Sludge conditioning, Operational experience

This study provides experimental, operational, design, and cost data from extensive filter pressing testing of clarification sludge conditioned by a polyelectrolyte. A pilot press was utilized to evaluate the dewatering of sludge from three water utilities. Filter pressing of sludge from the Hodder water facility was successful. A full-size filter press was installed. Filter washwater is dosed with a polyelectrolyte. The mixture undergoes two stage settling. The final supernatant is discharged to a river and the sludge is withdrawn from the settling basins and stored for pressing. Details of the press design features and operation are provided. Operational experience is discussed including information on sludge thickening, cyclic operation, power, economy, pipework and valves, automatic control systems, filter cloths, and mechanical handling equipment. Capital, running charge, debt charge, and comparative costs are tabulated. Conclusions based on operating experience are made on the press cycle, degree of system automation, cloth materials, and equipment sizing.

Hilson, M.A., "Sludge Conditioning by Polyelectrolytes," Paper of Fylde Water Board, Blackpool, Lancashire, England.

Key Words: Mathematical models, Sludge disposal, Sludge conditioning, Polyelectrolytes

This study defines the nature of polyelectrolytes and provides instances where these natural or synthetic polymers made clarification sludges more amenable to dewatering. Polyelectrolyte effectiveness can be influenced by seasonal water quality changes. At the Fishmoor plant, sludge is withdrawn from the sedimentation basins and stored. The stored sludge is then transported to a mixing tank where a polyelectrolyte is added. The mixed sludge is gravity fed to a thickener. At the Stocks plant, polyelectrolyte is added to the washwater. The washwater is then settled. Laboratory jar tests to evaluate polymers for sludge thickening efficiency concentrate on the rate of flocculation, floc size, settling rate, and water clarity. Sludge dewatering by filter pressing is predictable by the Carman-Kozeny and D'Arcy equations. The compressibility index and specific sludge resistance primarily affect the dewatering properties. A procedure is presented to evaluate these parameters in the laboratory. Plans are explained to study the conditioning of lime softening sludges. Cost considerations are enumerated.

Brown, A., and Leighton, J., "Some Solutions to Sludge Treatment Problems at Fishmoor Treatment Plant," Paper Presented at Fishmoor Treatment Plant, England (1966).

Key Words: Costs, Freeze-thaw tests, Filter pressing, Polyelectrolytes

This study presents design and cost data for the filter pressing, freezing, polyelectrolyte conditioning, and lagooning of clarification sludge. The initial sludge dewatering facilities planned for Fishmoor include slow stirring thickeners, sludge retention bunkers, and freezing tanks. Sludge solids concentrations and quantities are listed. Operational difficulties are discussed. The thickener did not function adequately. The thickener was modified and testing was initiated with a Davy Paxman Vacuum Filter, Walmsleys Ltd. Rotoklene Strainer, filter press, and polyelectrolyte sludge conditioning agents. Design, operational, and construction details of a polyelectrolyte conditioning system are presented. Design parameters and operation experience are discussed for the filter press. Lengthy contruction considerations are enumerated for the freezing tank design. The freezing cycle time is related to sludge volume, refrigeration area, and freezing efficiency. Capital, operating and maintenance, power, and chemical costs are presented for the major processes employed.

The Manchester Corporation Waterworks of England reports "work on polyelectrolytes as coagulant aids and for the pre-treatment of sludge pressing has continued since 1966, and the results will be published shortly by the Society for Water Treatment & Examination."

The Copenhagen Water Department in Denmark has taken advantage of the natural freezing process to treat their clarification sludge. The Department states "we are able to inform that the Copenhagen Water Supply has run a lagoon plant for alum sludge during 7 years, using natural frost as a means of reducing the volume of the aluminum hydroxide sludge. This has till now, in our opinion, been a great success, but no special report has been issued stating details. The sludge is reduced to negligible quantities when frozen, and till now it has not been necessary to remove the remainder."

The Water Resources Association of England has been contacted to determine the type and status of work on water treatment plant waste control. The Director of W.R.A. plans to establish an exchange of information between the W.R.A. and the working committees of the Research Foundation. The Research Foundation looks forward to the exchange of information with the W.R.A. that will result in the development of new or modified treatment methods that will benefit the water utility industries of both countries.

Literature Searches

Several reports on the treatment of wastes from water utilities have been published since the report on the "Disposal of Wastes from Water Treatment Plants." These articles, appearing in water utility trade publications, have been abstracted in accordance with the specifications of the Water Resources Science Information Center. The abstracts follow.

Albertson, O.E., and Guidi, E., "Centrifugation of Waste Sludges," WPCF JOURNAL, 41, No. 4, pp 607-628 (1969).

Key Words: Centrifugation, Cost comparisons, Process variables, Case studies

A brief history of the application of centrifugation for the dewatering and thickening of domestic and industrial wastes is presented. This paper describes the utility of basket, disc, and solid-bowl conveyor centrifuges. A detailed study of design and process variables, including bowl design, bowl speed, pool volume, conveyor speed, feed rate, feed consistency, temperatures, and flocculants is given to show the versatility of solid-bowl centrifugation. Reference is made to specific test facilities where case studies have shown this dewatering technique can effectively handle raw primary and secondary sludges, digested primary and secondary sludges, pulp and paper wastes, and water softening sludges. Cost comparisons have been made evaluating sludge treatment by vacuum filtration, solid-bowl centrifugation, and chemical flocculation. Centrifugation competes favorably with these processes when operating, maintenance, and capital costs are considered.

Middlebrooks, E.J., and Phillips, W.E., and Coogan, F.J., "Chemical Coagulation of Kraft Mill Wastewater," Water & Sewage Works, 116, No. 3, pp IW 7 - IW 9 (1969).

Key Words: Coagulation, Chemical oxygen demand, Organic polymers, Aluminum sulfate

This study shows that colloidal suspensions containing significant proportions of color, suspended solids, and chemical oxygen demand material in paper mill wastewater can be removed by chemical coagulation with organic polymers. Analytical grade aluminum sulfate and 6 organic polyelectrolytes were tested on kraft mill wastewater. Previous work with synthetic polymers and ferric sulfate is referenced. The coagulants were tested on grab samples and composite samples from the raw waste stream. The jar test procedure and parameter analysis techniques are explained. The organic polymers were equally effective in reducing chemical oxygen demand material, color and suspended solids. The aluminum sulfate was effective but tripled the sludge volume produced by the organic polymers. The coagulation efficiency changed with variations in the solution pH. None of the coagulants utilized could significantly reduce the biochemical oxygen demand of the waste.

Hamblin, C.W., "Recalcining Lime Sludge Produces Multiple Benefits," The American City, 84, No. 11, pp 67-69 (1969).

Key Words: Carbon dioxide, Water softening, Lime-recalcining, Washwater recovery

This study shows how lime recalcining and washwater recovery at a municipal water utility can reclaim 9800 tons of 92 percent pure quicklime, 9950 tons of carbon dioxide and 170 million gallons of washwater annually. Extensive modifications to the existing facilities will permit handling of the 23,000 tons of dry solids produced annually while extending the life of sludge storage units and controlling air pollution. Sedimentation of filter washwater is accomplished in separate settling basins. The carbon dioxide produced from the recalcining facility will be used to stabilize the softened water. It is expected excess quicklime can be recovered and sold to reduce plant operating costs. A flow diagram of the 60 ton per day vertically constructed fluid bed type recalcining system is presented. Fuel requirements are 9 million Btus/ton of product output. Tables show chemical characteristics of the lime sludge and the equipment required for construction.

Fulton, G.P., "Disposal of Wastewater from Water Filtration Plants," AWWA JOURNAL, 61, No. 7, pp 322-326 (1969).

Key Words: Pollution abatement, Concentration, Sludge freezing, Alum recovery

Processes for the successful treatment and disposal of potential pollutants from settling basin underflows and filter backwash water were examined to identify pollution abatement techniques. Limited physical and chemical characteristics of wastewater were qualitatively and quantitatively reviewed to evaluate sludge freezing, alum recovery, and vacuum filtration operations. Consideration was given to the disposal of water plant wastes in local sewage systems. Treatment goals of concentrating wastes and making these wastes suitable for disposal are discussed. Treatment cost is reportedly minimized by simplifying operations for personnel and limiting land area unit requirements. A settling rate of 250 gpd per sq. ft. was found acceptable for settling alum sludge, in its semifluid state, by using mechanical thickeners. The advantages and disadvantages of the treatment schemes are presented. Sludge freezing and alum recovery processes are referenced to plant scale operations.

Keith, F.W., "Centrifuges Concentrate and Dewater Waste System Solids," Water & Sewage Works, 116, No. 3 , pp IW 10- IW 18 (1969).

Key Words: Centrifugation, Dewatering, Scroll centrifuge, Electrochemical machining

The utility of centrifugation as a concentrating mechanism to treat municipal sewage sludge and paper, petroleum, and electrochemical machining waste water is discussed. The study reveals that centrifugation processes can clarify waste streams in a primary treatment capacity or provide supplemental treatment by dewatering concentrate streams from flotation and thickening processes. Design features and waste stream parameters are presented for scroll and disc type centrifuges. The scroll centrifuge is most effective when there is a high solids loading and a high concentration cake is desired. The disc centrifuge can handle finer sized particles economically and is suitable for dewatering activated sludge. The applicability of centrifugation to concentrate waste activated sludge, to prepare primary and secondary sludge for incineration, and to treat electrochemical machining wastes is referenced.

Scott, J.C., "Ann Arbor's Recalcining Process and Problems," AWWA JOURNAL, 61, No. 6, pp 285-288 (1969).

Key Words: Reclamation, Lime recalcining facility, Costs

Although a comprehensive report on Ann Arbor's water needs showed that the lagooning of lime sludge is an adequate disposal technique, the development of a lime recalcining facility was undertaken. The cost of the 24 ton per day lime reclamation facility is estimated at $1,200,000, including handling and treatment of the sludge from the clarifier to the finished lime storage tanks. This paper outlines the basic format of the process methodology from the lime sludge withdrawal to a lime product. The problems associated with this installation are those arising from personnel requirements, type of operation, characteristics of sludge collected, winter equipment maintenance, and other equipment needs. The cost estimate is shown to be highly variable and a study of the proposed site and surroundings among other factors must be carefully evaluated. The problems are related to construction, maintenance, and operating costs.

AWWA Committee, "Diatomite Filtration Sludge Disposal," AWWA JOURNAL, 62, No. 8, pp 507-509 (1970).

Key Words: Solid wastes, Liquid wastes, Diatomite filtration, Slurry disposal

The purpose of this study is to provide information on the problem of sludge disposal from diatomite filtration operations with specific consideration given to potable water treatment. A table is presented comparing the characteristics of plant process wastes from diatomite filtration and conventional filtration plants. Several slurry disposal methods are discussed. Although a diatomite filtration slurry is stated to be a good soil conditioner for agricultural lands, the discolored waste material is esthetically objectionable. The advantages and disadvantages of disposing slurries to sewerage facilities are enumerated with consideration given to the abrasive and settling nature of the waste. Settling lagoons, vacuum drum filtration, and pressure bag filtration are suggested as solids separation techniques. Disposal of liquid wastes can be accomplished by discharge to sanitary sewers and recovery. Solid wastes will provide good landfill. A number of secondary waste uses are listed.

Faber, H.A., "Research on Water Treatment Plant Waste Disposal," Water & Sewage Works, 117, No. 11, pp 379-383 (1970).

Key Words: Freezing, Dewatering, Centrifugation, Lime recovery, Economical disposal

This survey highlights active research, demonstration, and in-plant studies of sludge and filter washwater disposal. The problem of economical waste disposal techniques for purification and softening plant sludges is being investigated in various areas. The disposal of aluminum and ferric hydroxide sludges and the recalcination of lime sludge are enumerated for several dewatering processes. The survey cites references to freezing, centrifugation, precoat vacuum filtration, thickening, filter pressing, and lagooning procedures. Water reuse and phosphate removal systems are also listed. Projects examining sludge conditioning through chemical addition, and operations substituting polyelectrolytes as primary coagulants to treat filter washwater or raw water are discussed. A systematic program for the organization, coordination, and dissemination of research and demonstration projects is stressed. A central information resource program would promote pollution control technology beneficial to the water utility industry.

Bugg, H.M., and King, P.H., and Randall, C.W., "Polyelectrolyte Conditioning of Alum Sludges," AWWA JOURNAL, 62, No. 12, pp 792-795 (1970).

Key Words: Zeta potential, Polymer conditioning, Specific resistance

Data show that alum sludge is more amenable to dewatering by gravity drainage or vacuum filtration with polymer conditioning. Water plant wastes are potential pollutants containing metallic ions and organic material that deplete the oxygen resources of a watercourse while inhibiting natural biological activity. The polymers investigated were 2 cationic, 2 nonionic, and 3 anionic polyelectrolytes manufactured by Nalco. Jar tests showed that sludge-polmer mixing beyond 2 minutes caused a break up in the agglomerated floc. The cationic polymers were effective over a low pH band and the other polyelectrolytes were efficient in the pH 6.0 to 10.0 range. Anionic polymers performed best at the 2 percent sludge concentration and unadjusted pH of 6.6. Data are presented for the parameters of specific resistance and zeta potential for conditioned and unconditioned sludge. Bench-scale sand-bed drainage studies on a 4.2 percent alum sludge showed that conditioned material with 100 mg per liter of anionic polymer dewatered in one-fifth the time of unconditioned material.

Francis, P., and Knight, H.W., "The New Langford Treatment Works of the Southend Waterworks Company," Water and Water Engineering, 74, No. 894, pp 319-327 (1970).

Key Words: Construction, Hydraulic design, Lime-soda ash softening, Recycling

This article describes the site, layout, foundation, administration and plant specifications for a 12 million gallon per day lime soda softening facility. In addition to the softening process, construction and hydraulic design considerations are outlined for the prechlorination, hydrogen ion concentration adjustment, gravity filtration, chlorination, and dechlorination processes. The lime soda sludge is concentrated to 7000 gallons per hr. and pumped at a rate of 3½ feet per second through 4 inch PVC piping to a gravel pit. The sludge settles and the supernatant effluent from the pit is recycled to the plant intake line. Details are provided on the treated water pumping station and the architectural features of the utility. The main contractors and contract costs are listed. A history of the operating record of the Southend Waterworks Company is presented. A diagram of the water treatment processes and the site layout is included.

Degremont, S.A., "The Orly Waterworks of the City of Paris," Water and Water Engineering, 74, No. 890, pp 135-146 (1970).

Key Words: Water purification, Sludge treatment, Orly waterworks, Alum recovery

This article describes the treatment technology utilized at a water purification plant employing a coagulant recovery process. This highly automated treatment facility handles a nominal flow capacity of 66 million gallons per day of Seine River water. Details of the pretreatment, clarification, filtration, sterilization, reagent storage and feeding, pumping, alum recovery, and monitoring, electrical, and control equipment facilities are provided. Filtration is accomplished under a 3.9 foot head of water. This head is required to prevent the degassing of the process water in the filters during low and hot weather flows. The sludge from the clarification units is concentrated at 8 grams per liter and then acidified with sulfuric acid to pH 3 to 3.2. The acidified sludge is fed to settling basins where the aluminum sulphate solution is recovered. The remaining sludge is neutralized with calcium carbonate in separate tanks. Physical and chemical characteristics of the water at different stages of the treatment process are presented. A flow diagram of the plant is also provided.

Welch, A.W., "Reclamation of Filter Backwash Water," Water & Sewage Works, 117, No. 7, pp 189-190 (1970).

Key Words: Settling basins, Lagoons, Washwater recovery, Polyelectrolytes

This study stresses the importance of the disposal of sludge from settling basins and the disposal of filter washwater in water treatment plant pollution abatement. A polyelectrolyte, Zeta Floc WA, is stated to produce a dense floc when added to filter washwater during the backwash cycle. The coagulating chemical is fed dry to the waste water stream and is capable of producing an 80 to 85 percent washwater recovery when the waste is settled in lagoons or a recovery basin. Data for a typical backwash of 6 to 8 minutes with 60,000 gallons of water showed that 8 to 10 pounds of polyelectrolyte were required at a cost of $.11 per pound. The sludge produced can be dewatered, recycled to the primary settling tanks, or utilized as a sewage sludge conditioner.

Fulton, G.P., "Alum Recovery for Filtration Plant Waste Treatment," Water & Wastes Engineering, 7, No. 6, pp 78-81 (1970).

Key Words: pH, Filtration, Alum recovery, Aluminum hydroxide sludge, Acidulation

A description is supplied of process considerations to be evaluated for alum recovery from an aluminum hydroxide sludge. The suspended solids content and other impurities contributing to the nature of the waste are examined with reference made to specific operating conditions and raw water quality. The advantages of a preliminary thickener before the acidulation step are explained. A settling basin overflow rate of 250 gpd per sq. ft. and a hydrogen ion concentration representing a pH of 2.0 is considered to enhance sludge settling in final solids separation. A 10-minute minimum detention time is suggested for the acidulation step. An alum solution between 1 and 2 percent should be obtained for an efficient operation. Filtration plants in the 200 to 500 mgd range with raw water suspended solids at 20 mg per liter indicate recovery costs to be $3 to $5 per million gallons of water produced. The utility of alum recovery is cited.

Mc Colgan, R., "Water Treatment Plant Wastes Disposal," Report of Orange County Sewer District, (1970).

Key Words: Injection wells, Water treatment plant wastes

The project goal was to determine effective treatment or disposal of activated carbon and aluminum hydroxide sludges and the neutralization of the waste supernatant before discharge to a lake. Sludge disposal techniques included injection wells and pipeline disposal to roadbase pits. Sludge treatment methods included gamma ray sludge destruction, dewatering, and filtration. Sludge injection caused clogging of the aquifer and elimination of the groundwater as a potential supply. Pipeline disposal created a dewatering problem in the roadbase pits. A 0.1 mg/l Nalco 671 polymer addition generated less sludge than radiation treatment and was as effective. Vacuum filtration, sand bed drying, centrifugation, and filter pressing concentrated sludge solids up to 20 percent. Basic research is recommended for sludge lagoons. Lagoon design considerations are a 2½ foot maximum depth, a 10 foot clearance for dump trucks, and a buffer zone between lagoons and residential communities.

Mc Colgan, R., "Waste Alum and Activated Carbon Sludge Solids Reduction Methods," Report of Orange County Sewer District, (1970).

Key Words: Waste storage, Landfills, Water treatment plant wastes, Lagoons

The study described a technique to limit alum and activated carbon sludge carryover from a w[illegible]te storage lagoon of a water treatment plant. Initially, buckets were dragged through the settling lagoon to remove the sludge. This technique re-suspended settled material and produced a carryover in the effluent. A new lagoon, 2½ to 3 feet deep, with a 2 to 1 slope was constructed. Pumping enabled a sludge transfer from the original primary lagoon to the new thickening lagooning. Sludge thickening was accomplished at the influent end of the lagoon, and the supernatant was recycled to the primary lagoon. The solids content of the thickened sludge was 6 to 10 percent. After additional drying, the sludge was used as a landfill.

Farrell, J.B., and Smith, J.E., and Dean, R.B., and Grossman, E., and Grant, O.L., "Natural Freezing for Dewatering of Aluminum Hydroxide Sludges," AWWA JOURNAL, 62, No. 12, pp 787-791 (1970).

Key Words: Snow cover, Freeze-thaw test, Lagoons, Natural freezing, Layered freezing, Filtrability

Data presented provide a basis for the design of lagoons for the dewatering of aluminum hydroxide sludge by natural freezing. Temperature considerations and convective heat losses are considered in the freezing experiments. The freezing rate of aluminum hydroxide sludge parallels the freezing rate of water. Field testing at Ely, Minnesota showed that a snow cover could reduce the freezing efficiency of the sludge, but careful management could minimize this problem by freezing the sludge in thin layers and removing snow from frozen layers. With complete freezing, the dewaterability and solids content of the sludge can be significantly increased. Freezing in a mild climate as Cincinnati, Ohio, would be successful in 1 inch layers. Layered freezing in partial freeze-thaw tests was not as effective as a complete steady freezing. The ratio of phosphorus to aluminum in the sulfate form is shown to barely affect the filtrability and solids content of aluminum hydroxide sludges.

Thomas, C.M., "The Use of Filter Presses for the Dewatering of Sludges," WPCF JOURNAL, 43, No. 1, pp 93-101 (1971).

Key Words: Dewatering, Filter presses, Chemical conditioning

The utility of a filter press to successfully dewater various wastewater treatment sludges is presented. The advantages of a filter press operation are cited for a specific range of application over alternative methods as centrifugation, thickeners, vacuum filters, and pressure filters. The enumerated benefits include efficient filtration even with feed characteristic variations, minimized maintenance, improved filtrate quality, facility in cake handling, and competitive capital costs. Design consideration should be based on theory and pilot testing. Additional requirements for filter pressing may include sludge storage tanks and mixers, chemical conditioning plants, feed pumps, filter cloths, interconnecting pipework and pressure vessels, and filtrate collection trays. Conditioning, filtration cycle, feed and cake characterization, and cake thickness data are presented for water plant sludge.

SECTION VII

SURVEY OF REGULATORY AGENCIES

Introduction

One purpose of the information resource project is to determine current problems and practices of regulatory agencies with respect to water treatment plant waste disposal requirements, and to identify measures contemplated to meet more stringent pollution abatement laws. A survey form was designed with the assistance of the Project Advisory Committee, to obtain new information on pollution control regulations. This survey was sent to regulatory agencies in March, 1971.

Historical Background

The AWWA Research Foundation published a survey, in its 1969 report on "Disposal of Wastes from Water Treatment Plants," on the regulatory aspects of the sludge disposal problem. The survey included ten questions relating to statistical, research, and regulatory information of sludge treatment requirements. The responding regulatory agencies submitted additional information on the problems and practices of water utilities within their area of control.

The 1968 survey showed that a majority of state and interstate regulatory agencies considered the discharge of wastes from water treatment plants to surface waters a violation of pollution control laws or regulations. Many of these agencies have laws or regulations applicable to the control or treatment of these wastes before discharge to surface waters. Several of the state, interstate, and territorial agencies could identify water treatment facilities controlling these wastes.

In 1953, Dean reported on a survey made of the state sanitary engineers. The survey questioned the engineers with respect to the discharge of sedimentation basin sludge and filter washwater into watercourses. The responses showed "that, in nearly every state, the health department or a commission or board has the authority to prevent the pollution of streams or lakes. Apparently these regulatory bodies are concerned with the disposal of sewage and industrial wastes and have usually not restricted the purification plants."

Summary of 1971 Survey

The 1971 survey by the AWWA Research Foundation indicates that the trend towards more stringent pollution abatement laws, as predicted by Dean and as illustrated in the 1968 survey, is becoming increasingly important. In the majority of cases, it will no longer be possible to design or operate a new water utility or modify an existing utility without providing adequate waste treatment facilities. In areas with growing population densities, the amount of wastes produced at water utilities will increase. Effective means to eliminate or alleviate the amount of pollution caused by these wastes will be required to meet state and federal legislation.

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Survey of Regulatory Agencies

The AWWA Research Foundation survey form was sent to the fifty states; District of Columbia; Guam; Puerto Rico; Virgin Islands; and eight interstate agencies. The survey was also sent to the ten Canadian Provincial pollution control authorities.

The response to the survey was excellent. Replies were received from the fifty states, District of Columbia, Puerto Rico, Guam, eight interstate agencies, and eight Canadian provinces. Some agencies did not have sufficient experience with these problems to complete all the questions within the survey. These agencies did provide several useful comments, presenting new material for dissemination.

The survey form (see Appendix) included eight questions requiring single or multiple choice responses. The survey was concerned with wastes from coagulation, softening, iron-manganese removal, diatomaceous earth, ion-exchange regeneration, filter backwash, desalination, and microstraining water treatment processes.

There were five statistical, two research, and one regulatory questions. The respondents were requested to complete the survey and to supplement it with any further information which would be helpful in our study.

Summary of Survey Responses

Question 1

Based on your Agency's experience, please indicate, in order of magnitude, your concern regarding wastes from the following water treatment processes (use numerals 1 to 8 with 1 as a major and 8 as a minor concern):

______ Coagulation

______ Softening

______ Iron-Manganese Removal

______ Diatomaceous Earth

______ Filter Backwash

______ Desalination

______ Ion Exchange Regeneration

______ Microstraining

Coagulation Processes

The wastes from coagulation processes were identified as of major concern by the regulatory agencies responding. Russelman (1968) reported the number of water utilities producing sludges from coagulation processes in the United States to be about 3,600. Coagulation wastes are variable in composition. The magnitude and nature of the waste are dependent upon the coagulants and other chemicals utilized in the treatment process, the efficiency of the treatment, variations in the physical and chemical constituents in the raw water supplies, seasonal variations in influent water quality, and the use of the drainage basin as effected by increased recreational, agricultural, industrial development, etc.

There are several waste treatment process alternatives available to control or concentrate the volume of waste material to be disposed. Processes to concentrate the solid materials in these sludge volumes include: cemtrifugation, lagooning, natural and artificial freezing, filter pressing, thickening, dewatering on sludge drying beds, vacuum filtration, and rotary precoat vacuum filtration. The recovery of aluminum sulfate from coagulation sludges, as a plant scale operation, has been accomplished in Tokyo and Paris. The reduction of the final solids in these wastes is increasingly important. The use of solid material for landfill is a disposal alternative to by-product recovery.

Softening Processes

The treatment and disposal of sludges from water softening installations was second in priority among the regulatory agencies. Chemically coagulated softening wastes contain calcium carbonate, magnesium hydroxide, and various inorganic and organic constituents depending upon the raw water supply source. Water supplies softening by means of synthetic zeolites or organic exchange resins, must regenerate the ion exchange units. Regeneration with a brine solution (sodium chloride) releases divalent metallic ions originally removed in the softening process, chloride ions, and excess sodium chloride. Both the chemically coagulated waste and ion exchange brine stream must be disposed of.

The Cities of Dayton, Ohio, and St. Paul, Minnesota, are examples of facilities chmically softening their supplies. Each treatment plant recalcines the calcium carbonate sludge. The calcium carbonate is reduced to quicklime and carbon dioxide. The carbon dioxide can be used for recarbonation of water in the treatment process following the lime softening step. Reclaiming lime and carbon dioxide from these wastes lessens the final solids disposal problems and reduces the operation cost of the facility.

A primary consideration in the recovery of lime from softening sludges for reuse is the build-up of impurities in the treated water. Magnesium, iron, and inert materials may be recirculated with the recycled lime.

The separation of magnesium compounds from softening sludge has been demonstrated at the City of Dayton, Ohio. Sludge withdrawn from the settling basins at this facility is carbonated. The carbon dioxide selectively converts the insoluble magnesium hydroxide to a soluble magnesium carbonate form. A physical process is then required to separate the soluble magnesium carbonate from the insoluble calcium carbonate.

Pilot facilities are being constructed at the City of Montgomery, Alabama, water treatment plant to demonstrate the utility of $MgCO_3$ as a recycled coagulant to remove color and turbidity from raw water.

The recovery of lime and production of magnesium carbonate for reuse as a purification coagulant minimizes solid wastes disposal problems. The recovery and recycling of chemicals for softening and purification plant treatment significantly reduce waste volumes.

Additional Process Wastes

The remaining area of concern in decreasing importance were: filter backwash water, iron - manganese removal wastes, ion exchange regeneration brines, desalination brines, diatomaceous earth filtration waste, and microstraining waste.

Filter backwash water can be recycled and the liquid portion of the waste recovered. Backwash water requirements are generally 1 to 5 percent of the daily plant flow. The backwash water represents a supply that has undergone treatment in the purification or softening plant. The recovery of backwash water through recirculation may be economically justifiable.

The sedimentation of filter backwash water in lagoons or settling basins provides another means of controlling the solid wastes. The supernatant from this sedimentation process can be discharged to a watercourse or recycled to the plant influent line, depending upon the water quality.

The recycling of filter washwater should be studied before being put into plant scale operation. The process might not be acceptable if bacteria are so highly concentrated in the washwater as to degrade the finished quality. This problem should be studied at each water treatment plant.

Research is being supported by the Office of Saline Water to study the recovery of chemicals and the evaporation of brine streams from desalination wastes. Several of the techniques developed might be adaptable for the treatment of ion-exchange brine streams.

The development of new or modified treatment technology demands responsible actions. The ability to maintain an integrated system of potable water production and waste control is important to comply with pollution abatement legislation. The control of pollution from water treatment plant wastes requires laboratory and pilot evaluation of processes, economic analyses of treatment alternatives, and planning to consider the possible uses of the source water. Versatility in design is necessary in the production of water and control of waste to counter seasonal and future water quality changes.

Comments

The State of Hawaii reported that it "obtains the majority of drinking water from groundwater supplies which require no treatment."

The State of Kansas reports that "wastes from softening, ion exchange regeneration, desalination, diatomaceous earth filtration, and microstraining are considered to be water pollutants. Iron - manganese removal, coagulation, and filter backwash wastes are not considered pollutants."

Question 2

> In determining treatment requirements for wastes from water treatment processes, does your Agency consider the following:

	Yes	No		Yes	No
TDS	____	____	COD	____	____
Settl. Solids	____	____	BOD	____	____
Susp. Solids	____	____	Chloride	____	____
pH	____	____	Color	____	____
Coliforms	____	____	Heavy Metals	____	____

Table 2, titled "Utilization of Waste Treatment Parameters", indicates the availability of specific data to characterize water utility wastes.

Each of these parameters has effects on downstream users, if the waste is discharged to a watercourse. The monitoring of waste parameters from water treatment plants defines the magnitude of the discharge on the quality of the receiving stream or river.

The discharge of wastes containing a high total dissolved solids concentration (TDS) may significantly change the quality of the water in the receiving stream. Depending upon the nature of the dissolved materials, intake and piping systems can be affected. In a large watercourse, the TDS concentration may be slightly altered. In a small stream, the TDS concentration may be significantly increased: it may affect aquatic life, and place the burden of lowering these solids to acceptable USPHS standards on a downstream user.

Settleable solids in waste streams require quiescent conditions for settling. They can settle in slow-moving watercourses, forming sludge blankets. Organic sludge undergoes anaerobic decomposition, producing nuisance by-products. Inorganic sludge inhibits the natural biological activity in a watercourse.

Suspended solids can be conspicuous and are aesthetically objectionable. Organic suspended solids may be aerobically and/or anaerobically decomposed and thus deplete the oxygen content of streams. The assimilative capacity of a watercourse is affected by the magnitude of biodegradable material it receives.

The pH of a raw water has an important effect in coagulation, disinfection, water softening, and corrosion control. A rapid and extensive pH change in a stream is detrimental to much aquatic life.

Coliform organisms, such as Escherichia Coli, are used as indicators of the presence of pathogenic bacteria. If the dilution capacity of the receiving stream is low, the discharge of water treatment plant wastes containing large numbers of pathogenic bacteria will impair the quality of the stream as a subsequent source of water supply. The coliform content of wastes, therefore, is a useful parameter for measuring the quality of the waste discharged.

The biochemical and chemical oxygen demands provide an indication of the oxygen requirements for stabilization of a waste. The utilization of oxygen by BOD and COD materials depletes the dissolved oxygen supply in a watercourse. Rapid oxygen depletions for significant time spans can seriously affect the more delicate biological activities.

Chlorides of 250 mg per liter produce objectionable taste problems in a water supply. The discharge of softening exchange brines changes the chloride concentration of the receiving stream.

Highly colored water is aesthetically unacceptable to most consumers. Color removal may be required as a treatment process to keep consumers from alternative sources, such as springs or wells which may be of unsafe quality.

TABLE 2

UTILIZATION OF WASTE TREATMENT PARAMETERS

Parameter	Respondent Agencies					
	State		Interstate		Territorial	
	YES	NO	YES	NO	YES	NO
TDS	31	12	2	2	1	1
Settleable Solids	41	2	4	0	2	0
Suspended Solids	40	3	4	0	2	0
pH	31	12	4	0	2	0
Coliforms	28	15	4	0	1	1
COD	18	25	2	2	1	1
BOD	18	25	2	2	1	1
Chloride	30	13	4	0	1	1
Color	29	14	4	0	1	1
Heavy Metals	28	15	4	0	1	1

The degree of heavy metal concentrations has not been considered a problem by water utilities until recently. This is principally due to the fact that analytical methods were not capable of measuring very low concentrations of trace metals. Standards for the toxicity levels of certain heavy metals have recently been established, and concentrations in wastes should be established.

The ten parameters listed affect downstream users by impairing water quality and reducing the assimilative capacity of watercourses. The extent of water quality degradation depends upon the relation of the waste flow to the river flow. The degree of treatment required for water utility wastes will be determined through the use of water quality or waste effluent standards.

Comments

The State of New Jersey indicates that "the degree of concern for all of these parameters depends on the particular receiving stream."

The State of South Dakota "expects to consider both color and heavy metals in the future" in determining waste treatment requirements from water utilities.

Question 3

Please indicate which of the following methods of sludge disposal would not be consistent with your Agency's regulation.

Discharge to Sanitary Sewers ______ Incineration ______

Barging to Sea ______ Landfill ______

Pipeline Transport ______ Agricultural Use ______

Please submit a copy of your Agency's regulations governing water treatment plant sludge.

Table 3, titled "Acceptability of Sludge Disposal Methods," illustrates the sludge disposal techniques that can be utilized by water treatment plants.

Comments:

The State of Alabama reports that "as of now, problems of waste from water treatment plants are relatively few in Alabama, represented by a few large plants. In view of this, we have adopted neither requirements nor regulations pertaining to these wastes, but may find it necessary to do so in the future."

The State of Colorado "doubts whether a municipality would allow a discharge to sanitary sewers. No specific regulations exist for water treatment plants. The requirement is to meet Water Quality Standards."

The State of California reports "pipeline transport depends upon the discharge point."

The District of Columbia reports "solids from one municipal water treatment plant do enter our sewer system at the present time. The discharge of waste to the sewerage system is presently under study.

The State of Maine reports " standards are not specific. Regulation depends upon general approval of the Department."

The State of Montana reports "no regulation at present. However, plants located on smaller streams have been requested to use sludge disposal facilities."

The Delaware River Basin Commission reports "no new facility may discharge sludge back to the river. Old facilities are being required to correct this method when they need to make adjustments or expansions."

TABLE 3

ACCEPTABILITY OF SLUDGE DISPOSAL METHODS

	Respondent Agencies	
Disposal by:	Acceptable Method	Unacceptable Method
Discharge to Sanitary Sewers	30 State	12 State
	3 Interstate	1 Interstate
	1 Territorial	1 Territorial
Barging to Sea	21 State	18 State
	4 Interstate	
	1 Territorial	1 Territorial
Pipeline Transport	31 State	4 State
	4 Interstate	
	2 Territorial	
Incineration	40 State	2 State
	4 Interstate	
	2 Territorial	
Landfill	41 State	2 State
	4 Interstate	
	2 Territorial	
Agricultural Use	42 State	1 State
	4 Interstate	
	1 Territorial	1 Territorial

The State of Oregon reports "any or all of the methods of sludge disposal may be satisfactory for a particular situation."

The State of Texas reports "municipal water treatment plant sludges are considered to be in the category of municipal solid wastes and are assigned to the Texas State Department of Health for regulatory control. Those generated by industry are regulated by the Texas Water Quality Board by specific waste control orders or regulations."

ORSANCO reports "all methods of sludge disposal would be consistent with appropriate controls."

The New England Interstate Water Pollution Control Commission reports "regulations should be developed by states and administered by them."

The States of Florida, Maryland, Massachusetts, Mississippi, and South Carolina report that they have no specific regulations governing water treatment plant sludge.

Some of the respondents have submitted regulations dealing in part with water treatment plant waste sludges. Other survey participants have referenced the control of these wastes to their water quality standards. Several of these responses follow.

The State of Arizona transmitted a publication from the State Department of Health titled "Rules and Regulations for Public Water Supply Systems."

The State of Arkansas transmitted a publication from the Arkansas Pollution Control Commission titled "Air Code and Water Quality Criteria for Interstate Streams for State of Arkansas."

The State of Idaho places water treatment plant wastes under regulations contained within the water quality standards. Copies of the "Idaho Drinking Water Standards" and the Idaho Water Quality Standards" were transmitted.

The State of Maryland transmitted a publication titled "Water Resources Regulation 4.8, General Water Quality Criteria and Specific Water Quality Standards."

The State of Minnesota transmitted "WPC 14, 15, and 23." These control laws are titled "Rules, Regulations, Classifications and Water Standards."

The State of Missouri transmitted a publication of the Missouri Water Pollution Board titled "Design Criteria to Treat Wastewater Discharges from Water Treatment Plants."

The State of Nevada reports "there are no regulations. There are Water Pollution Control Regulations adopted by the State Board of Health."

The Delaware River Basin Commission transmitted a publication titled "Administrative Manual - Part III, Basin Regulations - Water Quality."

The State of New Jersey transmitted a publication titled "Rules and Regulations for Approval of Public Water Supply Systems and Water Treatment Plants." Section 3.5 of this publication deals with wastewater treatment disposal. Section 12.4 applies to filter backwash water. These sections follow.

Section 3.5 Wastewater Treatment and Disposal

a. Wastewater, such as sludge from coagulation and sedimentation tanks and filter backwash water, shall ordinarily be treated before being discharged into any of the waters of this State. The degree of treatment will be contingent upon the character of the wastewater and its effect upon the receiving waters. Disposal of sanitary sewage shall be in accordance with existing statutes and regulations promulgated thereunder.

b. Unless otherwise approved, minimum treatment shall be plain sedimentation in lagoons. A minimum of two (2) lagoons shall be provided with a minimum total combined capacity equivalent to twenty-four (24) hours wastewater flow. They shall be designed with suitable baffles to minimize short - circuiting, and shall be provided with slow-release outlet devices.

c. Wastewaters containing high concentrations of dissolved solids shall be controlled as to discharge rate and the point of discharge, so as to meet the requirements of the Department for the specific situation.

Section 12.4 Backwash Water

d. Unless otherwise permitted, untreated filter backwash shall not be discharged to any of the waters of this State. (see subsection 3.5)

The State of North Carolina reports "we have no special requirements for wastes from water treatment processes. The streams in North Carolina are classified according to the best usage being made of the water in accordance with the Rules, Regulations, Classifications and Water Quality Standards Applicable to the Surface Waters of North Carolina."

The State of Ohio, Division of Engineering & Water Pollution Control Board, State Department of Health, transmitted information on the "Discharge of Wastes from Water Treatment Plants." Minimum quality requirements have been established for all waters of the state. Waste discharges from water treatment plants must conform to the requirements of the Ohio Water Pollution Board. These regulations follow.

"Minimum conditions applicable to all places at all times are as follows:

1. Free from substances attributable to municipal, industrial or other discharges; that will settle to form putrescent or otherwise objectionable sludge deposits;

2. Free from floating debris, oil, scum, and other floating materials attributable to municipal, industrial or other discharges in amounts sufficient to be unsightly or deleterious;

3. Free from materials attributable to municipal, industrial, or other discharges producing color, odor or other conditions in such degree as to create a nuisance; and

4. Free from substances attributable to municipal, industrial or other discharges in concentrations or combinations which are toxic or harmful to human, animal, plant or aquatic life.

   The following wastes from water treatment plants can no longer be discharged directly without treatment or other satisfactory control to the waters of the state.

   1. Sludge from settling tanks.

   2. Waste wash water.

   3. "Red" or "black" waste water from iron or manganese removal plants.

   4. Waste brine from ion exchange plants.

   5. Domestic sewage wastes.

   6. Other wastes.

The Ohio Department of Health has established the following program to achieve the results required by the Water Pollution Control Board:

1. All water treatment plants discharging wastes to the "waters of the state" will be placed under the permit system of the Water Pollution Control Board.

2. Water treatment plants not having acceptable facilities for handling of wastes will be required to install such facilities as a condition for future permits.

3. Provisions for handling of waste shall be included in the original construction for all new water treatment plants and shall be included in any construction for enlargement or substantial modifications of existing water treatment plants. These provisions must be included in all plans presented for approval after July 1, 1967.

4. Waste water from backwashing of filters at lime-soda softening plants and plain filtration plants cannot be discharged directly to the "waters of the state" unless there will be no problem in the receiving water. Designing engineers may present evidence to the Department if they believe that treatment of waste filter backwash water is not necessary.

It should be noted that adoption of criteria or standards by the Water Pollution Control Board in the future may require further upgrading of water quality criteria."

The State of Tennessee reports "this agency has no printed regulations."

The Commonwealth of Virginia reports "Virginia does not have regulations that pertain exclusively to water treatment plants. We consider the waste waters generated from water treatment plants as industrial wastes, thus, our regulations concerning industrial establishments would apply. The Commonwealth has "State Water Control Law" and "Water Quality Standards". The Commonwealth of Virginia is requiring all new water treatment plants being constructed to provide acceptable waste water treatment facilities. Virginia has not required the existing water treatment plants to install sludge treatment facilities, however, this is in our future program."

The State of West Virginia transmitted Section 17 of the amended publication titled "Administrative Regulations (1970)."

> Section 17. Water Purification Waste Water Control Measure
>
> 17.01 Waste Disposal - Provision must be made for proper disposal of wastes from water treatment plants. Such wastes include but are not limited to those eminating from sanitary facilities, laboratories, clarification facilities, softening facilities, and filter backwash. Discharges shall be governed by Chapter 20, Article 5A, Code of West Virginia and the following regulations:
>
> (a) The following means of waste and sludge disposal may be considered:

1. Lagoon design must provide the following:
    - (a) Location free from flooding.
    - (b) Dikes, deflecting gutters or other means of divert ing surface water when necessary.
    - (c) A minimum depth of 4 to 5 feet.
    - (d) Multiple cell.
    - (e) Adjustable decanting devices.
    - (f) Convenient cleaning.

2. Sludge beds for lime softening sludge or other sludges must provide the following:
    - (a) Location free from flooding.
    - (b) Multiple beds, each designed for at least one year's storage.
    - (c) Size of sludge beds will be governed by the concentration of solids disposed of with an ultimate depth of 12 inches dry basis.
    - (d) Distribution channels may be required for spreading sludge over entire area.
    - (e) Easy access roads and loading ramps with proper under drains must be provided.
    - (f) Tank Truck - Trucking wet sludge to agricultural lands or disposal areas requires proper handling, vehicles and equipment to permit hauling and spreading without creation of nuisances. It is necessary to provide sludge holding facilities for use during times that trucks cannot operate.

3. Community Wastewater Treatment Facility - Discharges to sewer systems and their treatment facilities depend on type of treatment, rate of discharge, plant design capacity, character of waste, and local conditions.
4. Other Methods-These include holding tanks, vacuum filters, centrifuging and recalcining. Detailed studies must be made to justify their use.
5. Sanitary Waste - The sanitary waste from water treatment plants, pumping stations, etc., must receive treatment. Waste from these facilities must be discharged either directly to a sanitary sewer system with approved treatment or to an individual waste disposal facility providing suitable treatment. The effluent must be acceptable for discharge to the surface of ground waters.

The states of Colorado, Connecticut, Iowa, and South Dakota have submitted water quality standards to govern these wastes.

Question 4

Please indicate which of the following methods of liquid disposal would not be consistent with your Agency's regulations:

Recycle _____ Sanitary Sewers _____

Stream Transport _____ Underground Injection _____

Table 4, "Acceptability of Liquid Waste Disposal Methods," shows the liquid waste disposal techniques that can be utilized by water treatment facilities.

Comments

The State of Alabama reports "underground injection is dependent on the individual case."

The State of Hawaii would not accept "stream transport if there is a violation of the State's Water Quality Standards."

The State of Idaho "would prefer pretreatment of waste prior to the discharge to sanitary sewers."

The State of Kansas states disposal method consistency "depends on the specific liquid and the volume. All methods would be possible."

The State of Montana reports "stream transport and sanitary sewers would not be consistent in some cases."

The Delaware River Basin Commission suggests "stream transport would be consistent after adequate treatment."

TABLE 4

ACCEPTABILITY OF LIQUID WASTE DISPOSAL METHODS

Disposal by:	Acceptable Method	Unacceptable Method
Recycle	42 State	2 State
	4 Interstate	———
	2 Territorial	———
Stream Transport	21 State	23 State
	3 Interstate	1 Interstate
	1 Territorial	1 Territorial
Sanitary Sewers	36 State	8 State
	4 Interstate	———
	2 Territorial	———
Underground Injection	25 State	19 State
	1 Interstate	3 Interstate
	1 Territorial	1 Territorial

Question 5

Please indicate whether your Agency requires water utilities to perform the following:

	YES	NO
a. Maintain records of waste production	___	___
b. Submit reports of waste production	___	___
c. Monitor waste receiving streams	___	___

Table 5, titled "Waste Production and Monitoring", shows the agencies that require maintenance and submittal of waste production reports, and monitoring of waste receiving streams.

Comments

The State of Colorado reports "regulations to this effect are being considered."

The State of California reports "the maintenance of waste production records is dependent upon the size and location of the water utility. Requirements are established on a case by case basis."

TABLE 5

WASTE PRODUCTION AND MONITORING

	YES	NO
Maintain records of waste production	10 State 1 Territorial	33 State 3 Interstate 1 Territorial
Submit reports of waste production	11 State 1 Territorial	33 State 3 Interstate 1 Territorial
Monitor waste receiving streams	5 State 1 Interstate 2 Territorial	39 State 3 State

The District of Columbia reports "solids are not discharged to the receiving stream when the water is clear. Material is discharged when the stream is heavy with sediment."

The State of Idaho "does not presently maintain records of waste production. The State monitors streams."

The State of Kansas reports "the maintenance of waste production records and the submittal of waste production reports will probably be required by 1975."

The Delaware River Basin Commission reports "these functions are required by the Basin states."

ORSANCO reports "contents of plant operating records are determined by the pollution control agencies of the signatory states of the ORSANCO interstate compact."

Question 6

Please indicate, in your judgment which of the following should be the major contributor in supporting research for treating wastes from water treatment plants (Question 1):

State Government ____

Federal Government ____

Water Utilities ____

Equipment Mfr. ____

Educational Inst. ____

Consulting Engineers ____

Table 6, titled "Major Contributors to Support Research," shows the institutions the agencies feel should provide the funds for water treatment plant waste research. Some agencies placed equal weight on two or more potential contributors.

Question 7

Please indicate, in your judgement, which of the following should conduct most of the research effort for treating wastes from water treatment plants(Question 1):

State Government ____

Federal Government ____

Water Utilities ____

Equipment Mfr. ____

Educational Inst. ____

Consulting Engineers ____

Table 7, titled "Major Conductors of Research Effort", shows the organizations each agency feels should conduct the research on treating water utility wastes. Some agencies placed equal weight on two or more organizations.

Question 8

Please indicate, if the wastes from a water treatment plant could be reduced to the same form as the wastes in the original source water, would your Agency accept the discharge of these wastes to a.watercourse?

YES ____

NO ____

If not, what standards would you require?

Table 8, titled "Acceptability of Discharging Reduced Wastes to a Watercourse", shows the number of agencies that would allow a waste of the same form as the source water to be discharged to a watercourse. The comments indicate "yes" replies were qualified.

Comments

The State of California reports "specific numerical criteria are established for each discharge. Discharges of sludge are generally prohibited."

The District of Columbia reports "the policy is that once wastes are removed, they are not to be returned to the receiving stream without treatment to an acceptable level. However, at the present time the policy is not followed and the problems of proper disposal of wastes from our municipal water treatment plants are under study. The District of Columbia Police Regulations, Sections 12, 18, & 19 should be noted."

TABLE 6

MAJOR CONTRIBUTORS TO SUPPORT RESEARCH

	Responding Agencies
State Government	3 State
Federal Government	35 State 3 Interstate 2 Territorial
Water Utilities	18 State 2 Interstate 1 Territorial
Equipment Manufacturers	9 State 1 Interstate 1 Territorial
Educational Institutions	6 State

The State of Hawaii responds "yes, if it is of the same quality as when it was taken out."

The State of Indiana reports "if wastes are concentrated, they should not be recommited to receiving waters. Any addition of plant waste would result in an increase of some sort in the receiving stream."

The State of Iowa reports "possibly yes if on a continuous discharge basis."

The State of Kansas reports "yes, but this position may have to be changed as a result of the Corps of Engineers implementation of the 1899 Refuse Act."

The State of Kentucky reports "yes, but this depends on the condition and water quality of the receiving stream."

The State of Massachusetts requires that "pollutants must be reduced by at least 80 percent and effluent must meet river classification requirements."

The State of Minnesota reports "no, use regulations WPC 14, 15, and 23."

The State of Missouri reports "no, under present regulations by the Federal Environmental Protection Agency it will soon become necessary to treat or dispose of all material once it has been removed in some manner, other than discharge back to the source."

TABLE 7

MAJOR CONDUCTORS OF RESEARCH EFFORT

	Responding Agencies
State Government	4 State
Federal Government	25 State 2 Interstate 2 Territorial
Water Utilities	11 State 1 Interstate 1 Territorial
Equipment Manufacturers	20 State 2 Interstate
Educational Institutions	19 State 2 Interstate
Consulting Engineers	2 State

The State of Montana responds "no, not unless from the aesthetic standpoint they were the same. On high quality waters there should be at least the removal of suspended and settleable solids."

The State of Nebraska reports "this question cannot be answered at this time because our Water Quality Standards indicate that there be no discharges of settleable or floating materials. Therefore, we are attempting to prohibit any wastes into Nebraska waters. Another responsibility of our Water Quality Standards is that of enhancing water quality. Therefore, if water is taken from a stream and the pollutants such as silt, and sand are removed, enhancement is realized. From the standpoint of practical application, Federal and State Water Quality Standards will have to be given careful study to determine whether or not the pollutants that were taken out of the water could not be returned. This, of course, does not permit the discharge of lime, aluminum sulfate, iron, manganese, calcium, magnesium and other undesirable minerals from a water treating plant. At the present time, these are all being discharged into sanitary sewers where they are removed with the sludge.

Omaha is now facing the problem of disposing of the silt, sand and other settleable solids from the Missouri River water supply in their treating plants. They face a huge landfill program if prohibited from returning to the River which they are now doing."

The State of New Hampshire reports "requirements of stream classification must be met."

The Delaware River Basin Commission reports "wastes would be accepted for discharge if they meet requirements."

The State of New Mexico reports "yes, at present. Most domestic water in New Mexico are from wells with no treatment involved except chlorination and some fluoridation. Farmington and Raton are the two larger supplies having water treatment including flocculation and filtration. The backwash from treatment plants could find its way into streams; however, due to the dry and arid nature of the state, this backwash material has not been considered a problem-perhaps it should. During periods of rain, streams are very muddy and turbid."

The State of Ohio reports "no, the enhancement of stream quality " would be required.

The State of Oklahoma reports "this depends on the particular sub-basin in the State. Some cases would be "yes and some cases no."

The State of Oregon reports "the problem is presently minimal in our State."

The State of Pennsylvania requires "at least 85 percent reduction of BOD, reduction of practically all suspended solids, and disinfection will be required."

The State of Tennessee reports "yes, if they could be returned at essentially the same conditions.

Standards require:

1. No more than 1.0 mg per liter settleable solids.
2. No distinctly visible floating solids.
3. BOD_5 limitations would be stipulated in accordance with receiving stream.
4, Chloride limits might be set where applicable.

This agency has no set, uniform standards relating to waste materials from water treatment plants."

The State of Texas reports "no, we require reasonable control of solids, sludge and other concentrated materials (salts,etc.) which result from the various water treatment operations."

The State of Wisconsin "does not have effluent standards at the present time, however, turbidity and solids would have to be be below an acceptable level."

TABLE 8

ACCEPTABILITY OF DISCHARGING REDUCED WASTES TO A WATERCOURSE

Acceptable Method	Unacceptable Method
21 State	17 State 3 Interstate 1 Territorial

Additional Regulatory Agency Survey Information

The State of Connecticut provided a list of water filtration plants which have washwater and/or sludge to dispose of, and the method of waste disposal utilized.

The Government of Guam reports that it "obtains the majority of its water requirements from groundwater, except in the case of the Fena River water.

Raw water from Fena Resevoir is combined with the spring supply and passes through a Venturi meter. Alum and lime are then added to the raw water in a mixing tank prior to its flow into a 1.25 million gallon circular clarifier. Activated carbon is also added at this point on the rare occasions that taste and odor control is needed. Chlorine gas is added to the clarified water prior to filtration. The plant has six anthrafilt filters. Sodium silica flouride solution and chlorine gas are added after filtration and before storage in a one-million gallon clearwell. It is possible to add chemicals before the Venturi meter and by-pass the Venturi meter mixing tank and clarifier.

Normally all filters are used and are backwashed at two-seven day intervals. Filter backwash and clarifier sludge are dumped into a nearby creek, causing pollution problems. There have been complaints of this, but the appropriate corrective action has not been decided. It would be possible to pond and evaporate the water, but downstream users want the water without the waste.

The State of Washington reports that "backwash water from water treatment plants has not in the past been the subject of an active control program in this state. It is safe to say that water treatment backwash water will be subject to some federal and perhaps state control soon, This amounts to one or two dozen water treatment plants discharging alum floc wastes with one or two small sodium zeolite softening units. Several of the filter plants are in the 10 to 30 mgd range, but the majority would be 1 mgd or less. Several have already been provided with sludge lagoons and in most cases the solution probably will be lagooning or discharge to municipal sewers."

A copy of a letter from the E.P.A. to the State of Washington, Environmental Programs, Division of Health was included. This letter "indicates clearly that the agency (E.P.A.) intends to become interested in this source of waste water. It also seems rather clear that such control will be at least coordinated, if not directly regulated, by the Environmental Protection Agency with the possible assistance of the Corps of Engineers."

The E.P.A. letter states in part "that waste discharge from water treatment plants will be subject to the permit provisions of Section 13 of the River and Harbor Act of 1899. This means it will be necessary for each purveyor operating a treatment plant to make application to the Corps of Engineers for such a permit if wastes are discharged to a navigable waterway (this includes practically all surface waters)."

Canadian Survey Responses

The collection of information on the control of pollution caused by wastes from water treatment plants was extended to obtain information from the ten Canadian Provincial regulatory agencies. Eight of these provinces have responded to the survey.

Question 1 - Canadian Replies

The Department of Health in Edmonton, Alberta, Canada, listed the wastes from the following water treatment processes as items of major concern in decreasing importance: softening, coagulation, filter backwash, iron-manganese removal, ion-exchange regeneration, diatomaceous earth, microstraining, and desalination wastes.

The Department of Health in Regina, Saskatchewan, Canada, provided the following list in decreasing importance: coagulation, filter backwash, iron-manganese removal, softening, diatomaceous earth, ion-exchange regeneration, desalination, and microstraining.

The New Brunswick Water Authority of Fredericton, New Brunswick, Canada, reports wastes from coagulation and filter backwashing operations of only minor concern.

The Prince Edward Island Water Authority of Charlottetown, P.E.I., Canada, states "groundwater is used exclusively on P.E.I. We do not have any experience with the wastes from the water treatment processes noted."

Question 2 - Canadian Replies

The Edmonton, Alberta, agency considers TDS, settleable solids, and suspended solids in determining treatment requirements for wastes from water treatment plants.

The Regina, Saskatchewan, agency considers settleable solids, suspended solids, coliforms, COD, and BOD for treatment requirements.

The Fredericton, New Brunswick, agency does not consider any of the ten parameters.

The Charlottetown, P.E.I. agency considers the following parameters in determining the treatment requirements for wastes from industries utilizing water treatment processes : suspended solids, pH, coliforms, COD, BOD, color, and heavy metals.

Question 3 - Canadian Replies

The Edmonton, Alberta and Regina, Saskatchewan agencies consider the disposal of sludge by barging to sea inconsistent with their regulations.

The Fredericton, New Brunswick agency indicates the treatment of sludge by discharge to sanitary sewers, barging to sea, pipeline transport, incineration, landfill, and agricultural use of these wastes are all consistent disposal methods.

The discharging of sludge to sanitary sewers and the barging of sludge to sea are not consistent methods with the Charlottetown, P.E.I. agency.

There are no specific regulations governing water treatment plant sludge reported by any of the Canadian Provincial agencies responding.

Question 4 - Canadian Replies

Edmonton, Alberta indicates that the underground injection of liquid wastes would not be consistent with their Agency's regulations.

Fredericton, New Brunswick would not accept the recycling and underground injection of liquid wastes.

Charlottetown, P.E.I. does not consider recycling and stream transport of liquid wastes as consistent disposal techniques.

Question 5 - Canadian Replies

The four regulatory agencies providing responses to this survey question do not require water utilities to maintain and submit records of waste production or monitor waste receiving streams.

Question 6 - Canadian Replies

The Edmonton, Alberta, Regina, Saskatchewan, and Charlottetown, P.E.I. agencies indicate that the Federal Government should be the major contributor in supporting research for treating wastes from water treatment plants.

Fredericton, New Brunswick agency indicates that State Government, Federal Government, and water utilities should make equal contributions in supporting research for treating wastes from water treatment plants.

Question 7 - Canadian Replies

Edmonton, Alberta and Fredericton, New Brunswick, respond that the Federal

Government should conduct most of the waste treatment research effort.

Regina, Saskatchewan, places the major responsibility on educational institutions.

Charlottetown, P.E.I., reports that State and Federal Government should share the conduct of major research efforts. The State Government could utilize consultants but local government must be involved in terms of reference, etc.

Question 8 - Canadian Replies

The four agencies responding to the survey question indicate that if the wastes from a water treatment plant could be reduced to the same form as the wastes in the original source water, they would accept the discharge of these wastes to a watercourse.

Fredericton, New Brunswick reports "we have only four filter plants in New Brunswick. These are very small. None of these plants discharge to a small watercourse."

The Department of Health Services and Hospital Insurance in Victoria, British Columbia, Canada, reports "this province has no more than four water treatment plants. There is very little restriction placed on the waste disposal from water treatment plants, and there is doubt whether any of them have a permit from the Pollution Control Branch for their discharge of waste products. The plants we have are for very small communities and they are insignificant."

The Water Resources Commission in Halifax, Nova Scotia, reports that "this Province possesses, within its boundries, very few water treatment plants of a type sophisticated enough to have sludge problems. To date, what few problems occur of this nature are readily resolved by disposal to receiving waters such as the open sea. We anticipate that this sort of problem will develop in time and, in view of the magnitude of our present problems with other forms of pollution, we have not yet started to consider the matter of sludge disposal from water treatment plants."

The Quebec Water Board in STE FOY, Quebec, Canada, reports that "in the province of Quebec, the treatment of such waste (water treatment plant waste) is not required. We are looking forward to adopt regulations to take care of that pollution source."

The Department of Mines, Agriculture and Resources, Clean Air, Water, and Soil Authority of the Government of Newfoundland and Labrador states "we do not consider we have a pollution problem at present with water treatment plant wastes. In fact, there are only four water treatment plants in the province, and the wastes from them holds an insignificant problem when compared with untreated sewage discharge."

SECTION VIII

WATER UTILITY SURVEY

Introduction

A water utility survey was prepared with the assistance of the Project Advisory Committee. The purpose of the survey was to inventory quantitative data and qualitative data on the character of wastes from water treatment plants. Survey questions were prepared convering the basic data of new and finished water, chemical additions, waste handling and treatment operations, waste production, and character of purification and softening sludges. The survey (see appendix) required the respondents to make several physical and chemical tests on waste products.

It was originally planned to specify the physical and chemical test procedures for the waste sampling and analysis. A special committee was organized to prepare standardized sampling, analysis, and categorization techniques for waste from water treatment plants. Work has been initiated towards this goal. It was necessary, however, to distribute the survey before the test procedures could be completed.

The survey was sent to 171 water treatment plants. At least one survey was sent to each state in the continental United States. The purpose of the information resource program and the importance of the survey was explained. The Research Foundation received ninety-four replies to this survey from the U.S. water utilities.

The collection of information was extended to ten Canadian water treatment plants and to seven desalting facilities identified through the Office of Saline Water.

The survey replies demonstrate that wastes from water treatment plants are highly variable in character. Data tabulations were made to show the range of values reported from the cross-section of water treatment plants surveyed.

Summary of Survey Replies

A summary of survey replies and special comments made by the respondents follows.

Basic Data on Water Treatment Plant Wastes

The physical and chemical nature of waste sludges produced at water treatment plants depends upon the quality of raw water, the processes utilized, and the effectiveness of the unit operations. Some basic parameters that define the magnitude of the waste treatment or disposal problem include: density of the dry solids; settling characteristics of the coagulated wastes; floc formation time and size; sludge concentration at time of withdrawal from basins; physical and chemical constituents in the sludge; filter washwater volumes and concentrations; and dewatering ability.

The quantitative and qualitative character of the waste resulting from water treatment depends primarily upon the quality of the raw water sources. Raw water sources can be influenced by seasonal variations, obviously affecting both the amount and type of potential pollutants that must be removed in producing a potable water.

Raw water quality may be significantly altered due to changes in the utilization of a watershed area. Multi-purpose reservoirs and the discharge of domestic and industrial pollutants to watercourses in highly populated areas will present new problems that will affect the type and degree of treatment required.

The selection of unit processes and chemicals and the operation of treatment facilities are contributing factors to the character of the waste. Integrated process designs are required to produce a finished water of high quality and minimize the waste products from purification and softening facilities. Plant design must incorporate much needed flexibility to cope with seasonal quality variations in the source water, the changing nature of the watersheds, and the development of new technology, such as the use of organic or inorganic coagulants to replace or aid existing coagulants. The utilization of polymers as primary coagulants, coagulant aids, and sludge conditioning agents will change the physical and chemical composition of wastes.

A chief goal, outlined by the Project Advisory Committee, should be the minimization of sludge volumes. Methods of desludging contact or sedimentation basins require careful study. Desludging may be continuous, cyclic, or intermittent. The methods of discharging wastes from basins is important in evaluating the type of equipment to be used for sludge thickening or separation operations.

The Research Foundation is not presently aware of any particular sludge thickening or separation method that is universally applicable. The treatment process finally selected to handle purification and softening sludges should be the result of careful laboratory and pilot plant scale evaluations of the most economical alternatives. Process selection should be directed towards producing waste components suitable for reuse and ultimate disposal without impairing water quality of downstream users.

The operating practice group members of the Project Advisory Committee suggested several parameters that could be readily available at the majority of water utilities to be contacted by the Foundation. These parameters include: raw water turbidity; raw water suspended solids; raw water hardness; treated water hardness; raw water total dissolved solids; and treated water total dissolved solids. The amount and type of chemical additions producing sludge was also included. These data help define the degree of solids produced and removed within the plant. The total solids entering the plant plus the chemical additions resulting in precipitates minus the total solids leaving the plant equal the solids removed.

The monitoring of basic data parameters is necessary to the designing engineer, manufacturers of equipment and supplies, and the water utilities. Before treatment processes at specific utilities can be modified or new treatment schemes developed, an inventory of constituents expected in the purification and softening process must be available.

Response to Water Utility Survey

Ninety-four treatment facilities responded to this survey. These plants process water from twenty-eight impounded, fifty eight river, seven groundwater, and one groundwater and surface supply sources.

Turbidity

The majority of water treatment plants utilizing surface and the combined supplies recorded turbidity of the raw water. Three of the plants treating groundwater did not measure this parameter. Turbidity generally is caused by the suspension of fine or coarse particles in a solution. Significant amounts of suspended materials are removed during the flow of surface water into ground supplies due to natural filtration in surrounding soil formations.

Suspended Solids

The raw water suspended solids were recorded at twenty impounded, thirty river, and three groundwater supply sources. The suspended solids determination shows the material that will be removed during sedimentation and/or filtration.

Hardness

The raw water hardness was measured at each facility except one treating a river source. The treated water hardness was recorded at each facility except one processing a groundwater source. The extent of hardness removal in a softening facility provides data for a designing engineer to determine if recovery of the lime is economical. The importance of recording hardness is necessitated by the effect of its potential scaling properties in water distribution systems.

Total Dissolved Solids

Both the raw and treated water total dissolved solids were monitored at most facilities. The partial demineralization of dissolved solids through chemical precipitation or ion-exchange presents data on solids production.

Total Dry Solids

The total dry solids produced in a treatment facility must be reused or disposed of. The total dry solids produced was defined in the survey as the total solids of the influent source water, the chemicals added for treatment of this water, minus the total solids of the treated water. The added chemicals are those resulting in a precipitate. These chemicals should include alum or ferric salts, polyelectrolytes, activated carbon, lime and/or soda ash. These should not include chlorine salts of ammonia or lime used only for pH connection.

Graphical Correlation

A graphical correlation of the total dry solids production and the raw and treated water quality character was attempted. Data were tabulated for the total dry solids production and the six basic data parameter. Data were arranged by the nature of the treatment process, and plotted on cartesian coordinates. Treatment classifications were: purification plants with impounded supplies; purification plants with river supplies; and softening facilities.

Graphical scatter was significant in each correlation attempted. Variations exist in the raw and treated water quality of water in different geological locations. Each utility has a different combination of basic data constituents. The treatment plant tailors each source water to acceptable drinking levels as recommended by the United States Public Health Service. In several instances, two purification plants treating impounded supplies remove nearly equal dry solids amounts, but combination of raw and finished water parameters may be markedly different.

Dry Solids Production.

Data collected for treatment facilities sharing a common discharge area with similar influent water quality and utilizing similar treatment may illustrate correlations. The record of dry solids production should be evaluated at a specific utility for a yearly period. The dry solids production can be correlated with basic data parameters and system-related variables such as temperature, treatment efficiency, runoff, etc. The yearly fluctuation of waste production is an important consideration for the design and operating requirements of integrated water-waste treatment systems.

Data Categorization

The general categorization of data from impounded, river, groundwater, and combined supply sources displays a trend of water quality. To be complete, the survey would require each treatment facility in the United States to provide data. Table 9 classifies the data received from the cross-section of survey participants the Research Foundation has contacted.

Water Treatment Plant Waste Handling and Treatment

Sludge Thickening

Waste volumes can be minimized by concentrating or thickening the sludge withdrawals from sedimentation basins and solids from filter washwater.

Volumetric sludge reduction alleviates the problem of final disposal and provides a starting point for the recovery of by-products. Water utilities of all sizes can thicken or concentrate their waste solids. Table 10 shows the treatment facilities of different capacities employed for thickening sludge withdrawals from sedimentation and/or contact basins.

Filter Backwash Recovery

The recycling and recovery of the liquid portion of filter backwash water was suggested as a primary research need during the Project Advisory Committee meeting. The recovery of this water can be economically advantageous. Table 11 illustrates the number of treatment facilities that settle or recirculate filter backwash water to thicken the solids concentration and eliminate the discharge of suspended solid pollutants to other sources.

The Dalles, Oregon, Water Treatment Plant reports "we do not presently additionally concentrate or thicken sludge (slurry) withdrawals prior to disposal. We will soon be adding polymer to our sludge (basin sludge and filter washwater) as it goes to its new lagoon. This will enhance the settling rate of the sludge."

The East Bay Municipal Utility District reports "there is direct filtration and no sedimentation at their Lafayette, Orinda, and Walnut Creek plants. Sludge disposal is being evaluated at the Sobrante, San Pablo, and Upper San Leandro Filter Plants. Polyelectrolytes are being investigated. Some changes will be made."

The Chester Water Authority of Lancaster County, Pennsylvania, reports "sludge is held in lagoons. Later the sludge is removed and spread on the ground to dry before final disposal."

The Fridley Softening Plant in Minneapolis, Minnesota, reports "sludge beds concentrate sludge withdrawals prior to disposal. A sludge dewatering plant for concentration of softening plant sludge, filter backwash water and coagulation basin sludge will be in operation by November, 1972. Solids will be trucked to a dump."

The City of Atlanta, Georgia Water Department reports "they are building two pressure filtration plants now to concentrate sludge withdrawals prior to disposal ."

Characteristics of Solids

The character of the suspended solids in the wastes from sedimentation or contact basins and filter backwashing operations at the point of final disposal defines the waste treatment required to dispose or recover the solids. A highly concentrated waste is more readily adopted for use as a landfill or for by-product recovery. The great majority of purification and softening facilities surveyed reported that the wastes from basin desludging and filter backwashing were in fluid form at the point of final disposal.

TABLE 9

CATEGORIZATION OF SURVEY DATA PARAMETERS

		Sources		
		Surface-Impounded	Surface-River	Ground-water
Raw Water Turbidity	Mean	12	72	1
	Range	0.2-63	3-625	0-4
	Samples	27	58	3
Raw Water Sus. Solids (mg/1)	Mean	33	90	1
	Range	0-250	1-658	0-2
	Samples	20	30	3
Raw Water Hardness*	Mean	93	119	324
	Range	5-249	10-297	199-625
	Samples	28	58	7
Treated Water Hardness*	Mean	93	101	175
	Range	21-251	15-297	50-475
	Samples	28	58	6
Raw Water TDS (mg/1)	Mean	175	237	377
	Range	27-1032	35-737	230-600
	Samples	27	37	5
Treated Water TDS (mg/1)	Mean	166	196	225
	Range	40-1033	21-680	100-405
	Samples	28	45	5

* - mg/1 as $CaCO_3$

The suspended solids concentrations in sludge withdrawals from sedimentation or contact basins was reported from as little as 0.05 percent to 100 percent dry solids by weight. The former figure represents a waste that undergoes no thickening other than sludge compaction within the basins. The latter figure represents utilization of by-products from the waste sludge, recalcination of lime softening sludge.

The suspended solids concentrations of filter washwater were reported from 0.03 percent to 6 percent dry solids by weight and from 1 to 1420 mg per liter. The comparison of waste concentrations from filter washing operations is dependent on the establishment of standardized sampling, analysis, and categorization techniques to examine water treatment plant wastes. The variation in solids concentrations is significantly different, depending on the time and method of washwater sampling. A uniform

TABLE 10

CONCENTRATION OF BASIN SLUDGE

Average Flow Range (mgd)	Supply Source	Number of Facilities	Method
0-5	River	2	Settling
0-5	Groundwater	1	Settling
>5-10	Impounded	2	Settling
>5-10	River	1	Settling
>10-20	Impounded	1	Settling
>10-20	River	1	Settling
>20-30	Impounded	2	Settling
>20-30	River	1	Settling
>30-50	Impounded	2	Settling
>30-50	River	1	Settling
>30-50	River	1	Settling, thickeners
>50-80	Impounded	4	Settling
>50-80	Impounded	1	Centrifugation
>50-80	River	1	Settling
>50-80	River	1	Mechanical thickeners
>50-80	River	1	Drying beds
>50-80	Groundwater	1	Centrifugation
>120-200	River	1	Settling

TABLE 11

CONCENTRATION OF FILTER WASHWATER

Average Flow Range (mgd)	Supply Source	Number of Facilities	Method
>5-10	Impounded	1	Settling
>5-10	Groundwater	1	Settling
>10-20	Impounded	1	Settling
>20-30	Impounded	1	Settling
>20-30	River	1	Recycle to flocculators
>20-30	River	1	Lagoon drying
>30-50	Impounded	1	Settling
>30-50	Impounded	1	Lagoon
>30-50	River	1	Settling
>30-50	River	1	Clarifiers
>50-80	Impounded	1	Settling, Recovery
>50-80	Impounded	2	Recycling
>50-80	Impounded	2	Lagoon
>50-80	Impounded	1	Settling
>50-80	River	1	Recycling
>50-80	Groundwater	1	Recycled
>80-120	River	1	Pressure filters

sampling technique did not accompany the survey. Comparisons will be possible only when standard methods are developed and utilized.

Similarly, sludge concentrations in sedimentation or contact basins, depend, in part, on the type of system and the manner of desludging. The degree of sludge compaction varies with the nature of the raw water impurities to be removed and the coagulants utilized. Continuous, cyclic, and intermittent desludging operations must be evaluated in terms of optimizing waste concentration and minimizing waste volumes.

Comments

The City of Atlanta, Georgia, expects that the two Beloit-Passavant pressure filtration units will concentrate the dry solids content of the sedimentation basin sludge to forty-five percent and the filter washwater waste to forty percent.

The City of Des Moines, Iowa, Water Treatment Department settles filter washwater in a stilling pond. This settling is effective in increasing the dry solids concentration to ten percent.

The City of Dayton, Ohio, Water Department thickens, centrifuges and recalcines their lime sludge. The Department reports "all solids are reclaimed or recycled. Ninety-five percent of the solids are recalcined. The only solids necessary to lagoon are a small percent from the lime plant."

The Gary - Hobart Water Corporation concentrates sludge from their settling basins to six percent dry solids by settling.

The City of St.Paul, Minnesota, Water Department operates a lime reclamation facility at this softening plant. The lime recovery treatment consists of centrifugation and recalcining of sludge from the settling basins. Pellets of calcium oxide are reclaimed for reuse.

The City of Columbus, Ohio, Water Department recycles the filter backwash water to the sedimentation basins of the main plant. The solids from the filter washing are removed with the sludge withdrawals from the sedimentation basins. The wastes from the basins are settled and concentrated to forty-five percent dry solids.

The Chester Water Authority of Lancaster County, Pennsylvania, settles filter washwater wastes in lagoons. The wastes are periodically removed from the lagoons and placed on sludge drying beds. The dry solids content has been increased to fifteen percent by this method.

Table 12,titled "Disposal Techniques for Basin and Filter Washwater Solids, and Liquid Wastes", shows the techniques utilized for final disposal of these waste volumes at the utilities surveyed.

Several alternative techniques were reported in use to dispose of solid and liquid water treatment plant wastes. Table 13, titled "Techniques Employed for Final Disposal of Solid and Liquid Waste", illustrates the methods used.

TABLE 12

DISPOSAL TECHNIQUES FOR

BASIN AND FILTER WASHWATER SOLIDS, AND LIQUID WASTES

Disposal by	Responding Water Utilities Basin Solids	Filter Washwater Solids	Liquid Wastes
Watercourse	31	36	54
Lake	7	7	9
Dry Creek	4	4	5
Ocean	1	1	1
Lagoons	15	11	5
Sewer	8	7	9
Landfill	9	6	---
Agriculture	1	1	---
Recalcining	1	0	---
Other	4	8	8

Comments

The Chester Water Authority of Lancaster County, Pennsylvania, reports "sludge is given to an organic compost plant. They add it into their process in the manufacture of organic fertilizers."

Waste Production and Waste Characteristics

There are few alternatives for disposal of dried or concentrated waste solids. The solids must be disposed of in a manner consistent with the regulations of the authorized control body governing wastes from water utilities. By-products from the purification and softening processes can be recovered for reuse and/or resale. Inert materials that cannot be utilized remain for disposal . By-product recovery has been practiced when it is economical.

The magnitude of final disposal problems for solids wastes is partly dependent on the dry density of the solids. Thirteen treatment facilities

TABLE 13

TECHNIQUES EMPLOYED FOR FINAL DISPOSAL OF SOLID AND LIQUID WASTES

Basin Solids

Plants	Method
1	Settles solids in recovery pond and uses solids as a landfill
1	Discharges solids to sanitary storm sewer which discharges to a reservoir
1	Contract to have waste solids hauled away

Filter Washwater

Plants	Method
1	Settles solids in recovery pond and uses solids as landfill
1	Discharges solids to sanitary storm sewer which discharges to a reservoir
1	Contract to have waste solids hauled away
4	Recycles filter washwater to main plant intake
1	Discharges to a swamp

Liquid Wastes

Plants	Method
6	Recirculate liquids for recovery
1	Evaporation and percolation of liquid
1	Basin liquid wastes is lagooned followi [illegible] trifugation. Filter washwater is recycled.

reported dry solids densities of sludges from seventy-two to 141 pounds per cu. ft. These values include sludges from purification and softening plants. A standard density determination method did not accompany the survey.

The density value partially describes the volume required for a waste that has been completely dried. More important indicators of the waste volume to be treated or disposed are the water volumes needed for basin desludging and filter backwashing.

The water used for filter washing has been treated to a high level of quality. The recovery of this water seems to be an almost obvious solution that may significantly reduce plant operating costs and eliminate the pollution caused by discharging this waste.

The survey participants reported ranges of 0 to 21.8 percent of the treated water was required for basin desludging. In some cases, the treated water was recovered. Most utilities presently dispose of this solid and liquid waste from the basin desludging operation.

Filter washwater requirements ranged from 0.2 to 9 percent of the treated water used. Some plants reclaim this water.

The separation of solids from filter washwater and the recovery of the liquid portion of this waste demands consideration. The use of liquid-solids separation devices to reclaim filter washwater should be investigated. The suitability of separation technology such as microstraining should be examined if recycling or sedimentation of filter washwater is not feasible at a particular location.

The analysis of sludge samples from basins and filter washing operations depends upon the sampling method. Well defined waste sampling methods are currently being developed. A broad range of values for basin sludge and filter washwater sludge concentrations was found in this survey. Table 14, titled "Basin Sludge Concentration Data", shows the range of values reported.

Table 15 titled "Filter Washwater Sludge Concentration Data", demonstrates the variation in solids concentrations of filter washwater. By the nature of the filter washing procedure, a single measurement made on a single sample at a single time may be misleading. Several concentrations measured during the complete backwash cycle provide a temporal-concentration relationship. A plot of solids concentrations (mg/l) versus the time of backwash defines the solids release pattern of a particular filter. The more frequent the sampling of a waste during a backwash cycle, the more continuous are data points for the solids release curve. The area under the curve represent a time-concentration product (mg/l . min). With a constant backwash rate (gpm), the time-concentration product can be converted to total solids. Each filtration plant will have different relationships, dependent upon solids release patterns, rate of backwash, and total backwash water.

Table 16 titled "Chemical Analysis of Basin Sludge", provides a range of data accumulated from the purification and softening facilities responding to this survey. It is interesting to note that the largest response to any parameter was thirty-two participants (SiO_2). Of the ninety-four utilities included in this survey, the majority were unable

TABLE 14

BASIN SLUDGE CONCENTRATION DATA

Concentration Data		Supply Sources		
		Impounded	River	Groundwater
% of Dry Solids by Weight at Withdrawal Time	Range Samples	0.15-6 12	0.12-69[a] 18	4-4.4 2
% of Original Volume in 24 hr. settling and liquid decantation	Range Samples	0.9-75 10	0-89.6 17	17 1
% of Dry Solids by Weight in 24 hr. settling and liquid decantation	Range Samples	0.1-19 9	1.5-62 16	16 1
Suspended solids in supernatant in 24 hr. settling and liquid decantation (mg/l)	Range Samples	7.8-111,000[b] 9	1.5-2000 17	17 1

a - Pittsburgh, Pennsylvania
b - Columbus, Ohio

to supply much data on waste production and waste character. The regulatory information shows a trend toward the strict enforcement of existing legislation and the elimination of waste discharges from water treatment plants. Sampling, analysis, and categorization methods from water treatment plant wastes are being developed. The establishment of suitable sludge treatment processes at any water utility will require an analysis of waste production and character. These types of data will be necessary for laboratory, pilot, and plant scale design.

Table 17, titled "Chemical Analysis of Filter Washwater", illustrates variations in chemical analysis of purification and softening plant filter washwaters. The orderly classification of waste characterization data is an important step in treatment method evaluation.

Tables 18 and 19 illustrate the character of chemical and biochemical oxygen demand data of wastes from water purification and softening facilities. Table 18 contains data assembled from those purification plants responding to the survey. Table 19 is accumulated data on the water softening installations participating. The number of samples in these tables are quite small. The ability to measure and control these waste parameters will have added significance with the enforcement of state

TABLE 15

FILTER WASHWATER SLUDGE CONCENTRATION DATA

Concentration Data		Impounded	River
Average Dry Solids Concentration in Washwater (mg/l)	Range	0.35-3000	0.18-6888
	Samples	14	20
Average Dry Solids Concentration after 24 hr. settling and liquid decantation (mg/l)	Range	68-97,000	2.5-106,200
	Samples	8	17
Suspended Solids in Supernatant after 24 hr. settling (mg/l)	Range	2-35	2.5-330
	Samples	7	17

and federal water quality or effluent standard requirements. Water utility wastes represent one type of industrial waste input into streams. The chemical and biochemical oxygen requirements of these wastes utilize assimilative capacities of watercourses. The magnitude of this problem is proportional to several variables. These variables include: other waste inputs along the watercourse, reaeration coefficients in the streams, seasonal variation, decay rates of BOD material in streams, flow conditions, and others. The dissolved oxygen sag curve has been utilized to predict the effect of waste inputs in river basin systems. The oxygen deficits at each point in a stream can be predicted by using the principle of superposition for each waste source. Water utility wastes, added to other wastes, impair stream quality. The reduction or elimination of these wastes will ultimately be proportional to the degree of regulatory enforcement and the classification of the watercourse.

Additional Survey Information

The City of Laramie, Wyoming reports "all sludge from the sedimentation basins and filter washwater goes into a lagoon. When the lagoon fills up, it will be dewatered and the sludge will be spread on city owned property."

The City of Tucson, Arizona, "obtains its entire supply from deep wells, and the product water is distributed directly without treatment. Chlorine is added only to the water stored above the surface. The study of sludge disposal technology will become increasingly important to Tucson as this city looks forward to importing surface water as a supplemental source to be supplied through the Central Arizona Project, perhaps by 1980."

TABLE 16

CHEMICAL ANALYSIS OF BASIN SLUDGE

		Plant Type	
		Purification	Softening
Volatile Matter %	Range	1-50	2.88-82.75[d]
	Samples	20	8
SiO_2 %	Range	0.4-64	0.2-47
	Samples	20	12
Fe_2O_3 %	Range	0.2-57.4[a]	0.29-9.5
	Samples	18	11
Al_2O_3 %	Range	0-82	0-1.2
	Samples	19	9
$CaCO_3$ %	Range	1-86.6[b]	8.7[e]-98
	Samples	13	12
$Mg(OH)_2$ %	Range	0-24.3	0.35-14.9
	Samples	12	12
Remainder %	Range	0-77.9[c]	0.46-10.7
	Samples	12	8

a- as $Fe(OH)_3$ Providence, R.I.
b-San Diego Alvarado Plant
c-Cincinnati Water Works
d-Bismarck, North Dakota
e-Bismarck, North Dakota

The Water Supply Board of Providence, Rhode Island, reports "ferric sulfate is added as a coagulant to their water. Chemically treated water flows through a tangential mixer. Floc commences to form at the mixer, and the coagulated water enters the north basin. The flow in the basin is baffled to prevent short circuiting. The settled water then flows in the south settling basin. The combined capacity of the two series operated basins is 160.21mg. Average retention time for the two basins is over two and one-half days. Settled water from the surface of the south basin is treated with chlorine, filtered, and then fluoridated. The north basin is cleaned every two years, requiring about one week to drain, flush and refill. The south basin requires about ten days every four years for the same cleaning. The amount of flushing water is not monitored.

The time interval between discharges of basin sludge to the lagoon is quite long. The filter washwater is not stored in a tank or holding pond. The washwater with its solids flows from the washwater drain to the lagoons

TABLE 17

CHEMICAL ANALYSIS OF FILTER WASHWATER

		Plant Type	
		Purification	Softening
Volatile Matter	Range	0.5-40	4.5-99.06[e]
	Samples	15	3
SiO_2	Range	0.65-69[a]	0.1-18.8
	Samples	15	7
Fe_2O_3	Range	0.08-18.4	0.06-20.1
	Samples	11	7
Al_2O_3	Range	0[b]- 45	0-34.1
	Samples	13	6
$CaCO_3$	Range	1-55.8[c]	0.35[f]-98
	Samples	12	7
$Mg(OH)_2$	Range	0.3-22.1	0.1-6
	Samples	10	6
Remainder	Range	2-70.3[d]	0.53-54.41
	Samples	10	6

a - Rochester, N.Y.
b - Detroit, Michigan
c - San Diego, California
d - Pittsburgh, Pennsylvania
e - Bismarck, North Dakota
f - Bismarck, North Dakota

as the washing is in process. The solids in the washwater of course are different for each interval of time during backwash."

Canadian Survey Responses

Surveys were sent to ten Canadian water treatment facilities. Five responses were received by the Research Foundation.

The water purification plant in Hamilton, Ontario, treats water from the western end of Lake Ontario. This utility reports that "solids in slurrry withdrawals from sedimentation basins are concentrated by settling prior to disposal. The final disposal of water treatment plant sludge solids is to a creek emptying into Hamilton Bay, which is itself a large settling basin."

TABLE 18

CHEMICAL AND BIOCHEMICAL OXYGEN DEMAND CHARACTER OF PURIFICATION PLANT WASTES

Sludge Withdwawn From		BOD_5	COD
Basins	Range	0-350	6-23,000
	Samples	16	15
Filter Washwater	Range	0-25	4.5-200
	Samples	15	15
Liquid Waste @ Final Disposal From			
Basins	Range	2.8-350	16-7000
	Samples	11	10
Filter Washwater	Range	1.6-72.8	21.1-2617
	Samples	9	9

The Municipality of Metropolitan Toronto reports that "at the present time wastes from the four water treatment plants in Metropolitan Toronto are returned to the source, Lake Ontario. The Municipality is currently investigating this matter with a view to completely remove solids in the future before returning settling basin and backwash wastes to the lake."

The Department of Energy, Mines, and Resources of Canada reports to the Foundation that "the Government of Canada has built a fairly large Pilot Plant at Burlington, Ontario, to accomodate both basic and applied research on water pollution. It is expected to be in operation in about six months (early 1972). One of its main functions will be research and development into new and improved methods for the reclamation, reuse, and ultimate disposal of sludges, wastes from treatment processes, brines, etc. The Department plans to establish rapport with the Research Foundation, as a clearing-house to collect and distribute information and exchange data."

TABLE 19

CHEMICAL AND BIOCHEMICAL OXYGEN DEMAND CHARACTER OF SOFTENING PLANT WASTES

Sludge Withdrawn From		BOD_5	COD
Basins	Range	7.2-145	14.2-5000
	Samples	5	6
Filter Washwater	Range	0.7-14	5.6-300
	Samples	4	3
Liquid Waste @ Final Disposal From			
Basins	Range	3-145	6.5-5000
	Samples	7	3
Filter Washwater	Range	0.7-14	0.4-300
	Samples	4	2

The Region of Niagara, Niagara Falls, Ontario, Water Treatment Plant and the Petersborough, Ontario, Public Utilities Commission discharge the water treatment plant sludge solids to watercourses.

Desalting Facilities

Although many of the survey questions did not directly apply to desalting operations, several surveys were sent to desalting facilities. A general description of the operation at two facilities was received by the Research Foundation.

The Office of Saline Water operates a test facility at Webster, South Dakota, treating an average flow of 150,000 gpd of well water. This installation reports lime softening is utilized at this test facility to remove iron, manganese, and bicarbonate hardness prior to treatment by electrodialysis. Raw water total dissolved solids are reduced from 1500 mg per liter to 700 mg per liter in the treated water. The reduction in hardness is from 800 mg per liter as $CaCO_3$ in the raw water to 150mg per liter as $CaCO_3$ in the treated water.

Solids in sludge withdrawals from basins are concentrated to twenty percent prior to disposal. The water treatment plant basin solids are used as landfill. Filter washwater is discharged to a lake. The average total dissolved content of these waste waters is 1800mg per liter. This brine waste is discharged to a lake.

The Town of Buckeye, Arizona, reported on its electrodialysis plant. The raw water comes from deep wells with 1400 to 1800 ppm of total dissolved solids. The treated water from the electrodialysis plant contains 500 ppm or less of total dissolved solids. The total hardness of the raw water is from 8 to 12 grains per U.S. gallon. The treated water hardness is less than 3 grains per U.S. gallon. Impurities in the raw water are principally calcium carbonate, sodium, bicarbonate, chloride, and sulfate ions.

Following treatment in the electrodialysis plant, the major impurities with the exception of fluoride, are brought down within public health standards. The raw water has 4ppm of fluoride and the treated water contains 2ppm.

The waste stream from the water plant is concentrated to approximately 7500 ppm total dissolved solids before it is dumped to waste. The waste stream is mixed with the effluent from the sewage treatemnt plant with a resulting combination of approximately 2700 to 2800 ppm total dissolved solids. The farmers are satisfied with the effect of this combined effluent on their products.

Conclusions

The development of reliable research and development data is necessary in organizing an orderly approach to the control of pollution caused by water treatment plant wastes. Meaningful correlations and comparisons of waste parameters will benefit water treatment plants investigating or operating laboratory, pilot, or plant scale waste handling processes. The design of waste treatment facilities is dependent both on the physical and chemical waste character. A record of reliable data, accumulated through standardized sampling and analysis methods, will reflect seasonal changes and other important variations in waste content.

Two goals of the Research Foundation, confirmed by the analysis of this survey are:

1. To continue with the development of uniform sampling, analysis, and categorization techniques for water treatment plant wastes. Subject these methods, as developed under the coordination of the Foundation, for review and revision. Submit final methods to an appropriate Sub-Committee for review and incorporation in the next edition of Standard Methods For the Examination of Water and Wastewater.

2. To disseminate the standard testing procedures to the water utility industry and encourage the use of the procedures in the evaluation of water treatment plant wastes. These procedures must be utilized to provide a basis for comparison of waste problems.

SECTION IX

NEW TECHNOLOGICAL DEVELOPMENTS

Introduction

A principal goal of the AWWA Research Foundation is to coordinate and assist in the development of research and demonstration projects. It is essential that the information generated through this program provide the water utility industry with a basis for effective and economical waste disposal practices. As a clearinghouse, the Foundation serves to transfer technology and to exchange communication among scientific, technical, and administrative personnel in the identification of specific problems.

In the coordination of information, the Foundation is responsible for supplementing data presently available with plans for future research and demonstration requirements. New, and prehaps more imaginative, approaches to the control of water treatment plant wastes should be investigated.

Two needs were identified by the Project Advisory Committee for further development. These needs are:

1. The development of uniform sampling, analysis, and categorization techniques for water treatment plant wastes; and
2. The use of polymers in treatment processes to perform as primary coagulants, coagulant aids, and sludge conditioning agents.

A third approach to identify new developments was initiated by the Foundation: the availability of sludge dewatering devices from manufacturers of equipment required coordination. The suitability of different equipment to handle purification and softening wastes, and filter washwater should be presented. The Foundation has initiated work to accumulate this type of information.

The progress of each of these endeavors follows.

Standardization Sub-Committee

A Sub-Committee of the Project Advisory Committee was formed to develop documents for the uniform sampling, analysis, and categorization of water treatment process wastes. The Committee consisted of Messrs. Ralph Evans, H.O. Hartung, R.N. Kinman, and K.E. Shull. The Research Foundation functions as coordinator of the information developed.

The Research Foundation plans to:

1. Continue to coordinate activities in the development of the documents for standardized sampling, analysis, and categorization techniques for water treatment plant wastes.

2. Publish the finished documents and request reviews and comments from individuals on the Foundation's mailing list.

3. Transmit the final proposed procedures to the appropriate Standard Methods Sub-Committee to consider incorporating these methods in forthcoming editions of Standard Methods for the Examination of Water and Wastewater.

At the time of publication of this report, members of the Sub-Committee have submitted: (1) five tests which give basic information and which may be expanded into step by step standard methods; and (2) a laboratory procedure that has been successfully used by the Illinois State Water Survey in analyzing boiler scale or other scale occuring on the interior of water conveying conduits. These tests and analysis procedures will be building blocks in the construction of the final documents.

Five Basic Tests - Preliminary Contribution

1. Volume Per Cent Solids:

   a. 60 minutes settling

   b. 30 days settling

   The volume per cent solids can be determined by reading the settled sludge volume after settling 100ml of slurry in a 100ml graduated cylinder.

2. Weight Per Cent Solids:

   The determination of grams of dry solids in 100 ml of sludge can be made on an aliquot portion, dried for 24 hours @ 105 C.

   a. Solids Ratio = $\dfrac{\text{Volume PerCent Solids (60 minute settling)}}{\text{Weight Per Cent Solids (Dried 24 hrs. @ } 105^{\circ}\text{C)}}$

   b. Pounds of dry solids per cubic foot of slurry =

   0.623 x (grams of solids / 100 ml)*

   where o.623 = $28{,}320\ \dfrac{\text{ml}}{\text{ft3}} \cdot \dfrac{1}{100\text{ml}} \cdot \dfrac{\text{lb}}{454\text{gms}}$

   c. Slurry volume per 100 pounds of dry solids =

   $\dfrac{16}{\text{(gms of solids / 100ml)*}}$ cf

3. Specific Gravity of Slurry:

The specific gravity can be determined by weighing an exact volume of slurry in a laboratory specific gravity bottle.

$$\text{Specific gravity} = \frac{\text{Weight of given volume of slurry}}{\text{Weight of equal volume of water}}$$

4. Density:

The density can be determined on the weight per cubic foot of undisturbed, thickened, non-flowing sludge from the sludge lagoon. The method can be based on soils laboratory procedures using standard spoon sampling and cores.

5. Density of Solids (dried 12hrs @ 105°C - pounds per cubic foot):

The method is to add a known weight of dried solids to a specific gravity bottle completely filled with water. Weigh the displaced water.

$$\frac{\text{Pounds}}{\text{Cubic foot}} = 62.4 \times \frac{\text{weight of solids}}{\text{weight of displaced water}}$$

* Weight - Per Cent Solids in

The investigation of procedures to examine waste solids is still in a preliminary phase. These suggestions are methods used by the Illinois State Water Survey.

Scale Analysis

General Rules Applying to All Scale Analyses

1. All calculations will be made on the basis of the oxide of the element so that hypothetical combinations will be easier to calculate.

   For example:

   $$CaO + CO_2 \rightarrow CaCO_3$$
   $$CaO + SO_3 \rightarrow CaSO_4$$

2. All filtrations will be made using 15 cm, No. OK, ashless filter paper unless specific directions to the contrary are given.

3. Samples ignited in the electric muffle, whether ignited to 1000°C or 1100°C will be allowed to cool to 300 - 500°C in the muffle, then transferred to the 180°C oven for at least 1 hour, then placed in a desiccator to cool for 20 minutes before weighing.

Procedures for Analysis of Sludge

1. Preparation of Sample

a. Grind representative sample in agate mortar until a fine, powdery consistency is obtained.

b. Dry the sample at 105° for at least two hours or preferably over night so that all calculations can be made on a dry basis.

2. Organic and Volatile Matter (Loss on Ignition)

Weigh accurately about 0.5 gm of the prepared sample into an ignited porcelain crucible. Ignite to 1000°C. Cool and weigh.

$$\frac{\text{Loss of Weight} \times 100\%}{\text{Weight of the Sample}} = \%\ \text{Loss on Ignition}$$

3. Silica (SiO_2)

Weigh accurately about 1 gram of the dried sample into a platinum crucible. Add to the sample three or four scoops (#1A Scoop) of C.P. anhydrous sodium carbonate. Thoroughly mix the materials. (quantitatively) in the crucible. Cover the material in the crucible with two or three scoops of C.P. anhydrous potassium carbonate. Ignite to 1000°C.

After cooling, place the platinum crucible in a 400 ml beaker. Add 100 ml of doubly distilled water and 20 ml of concentrated HCL. Heat gently on the hot plate until no further evolution of CO_2 is noticed. Do not boil. Care must be taken to avoid spattering during the evolution of CO_2. Wash out the platinum crucible and remove it from the solution. Evaporate the solution to dryness on the steam bath and bake in the 105°C oven for at least four hours. This procedure is necessary to completely dehydrate the silica so that it will filter quickly and easily.

Cool, moisten the residue with concentrated HCL, then, after a short period of contact, dilute with doubly distilled water to a 10% acid solution. Boil for a few minutes, then filter off the silica. Wash the precipitate on the filter paper thoroughly, first with a hot solution of 1% HCL and then with hot doubly distilled water until the chloride ion is absent in the filtrate. Make filtrate up to 250 ml volume and save for later use. Ignite the residue in a platinum crucible to 1000°C. Cool and weigh. Carefully moisten the material in the platinum crucible with 1 to 2 ml of doubly distilled water, add 4 or 5 drops of 1:2 H_2SO_4 and then, carefully add 5 ml of HF. Place the crucible on the hot plate under the hood and evaporate to fumes of SO_3, then increase heat and fume off the SO_3. Ignite the platinum crucible to 1000°C. Cool and weigh.

$$\frac{\text{(original weight of precip. - remaining weight of precip.)} \times 100}{\text{weight of sample}} = \%SiO_2$$

note: If the amount of silica in the scale is large, it may be necessary to dehydrate the filtrate a second time to recover all of the silica.

4. R_2O_3

To a 100ml aliquot of the filtrate from the silica, add a few drops of concentrated HNO_3 and boil for a few minutes to oxidize all the iron to the ferric state. Remove from the hot plate, neutralize with concentrated NH_4 OH using methyl red indicator. Boil for a few minutes, add organic filter pulp and filter (save filtrate). Wash the precipitate with a hot 1% solution of NH_4NO_3. Ignite to 1000°C. Cool and weigh.

$$\frac{\text{weight of precipitate} \times 2.5 \times 100}{\text{weight of sample}} = \%\ R_2O_3$$

5a. Iron (Fe_2O_3 - Jones Reductor Method)

To a 100ml aliquot of the filtrate from the silica, add 10-20 drops of H_2SO_4, and evaporate to the fumes of SO_3. The solid mass at the bottom of the beaker should be straw colored $[Fe_2(SO_4)_3]$. Dissolve the mass in 100-150 ml of doubly distilled water, (the mass will dissolve more rapidly if the solution is kept hot by leaving it on the steam bath). This may take a few minutes to several hours. Cool the solution.

Clean the Jones Reductor by passing 3% H_2SO_4 through 3 - 4 times, then rinse the reductor with doubly distilled water. (A good test is to add a drop of KM_nO_4 to the rinse solution. If the reductor is clean, this will produce a pink color). Rinse again with 3% H_2SO_4. Pour sample through clean Jones Reductor using gentle suction to regulate the flow to under 75ml per minute. Do not allow the level of liquid in the reductor to fall below the zinc column at anytime. The zinc reduces the ferric sulphate to ferrous sulfate. Wash through 3 times with 3% H_2SO_4, then 3 times with doubly distilled water. Draw each portion through before adding the next. Wash the tip of the reductor off and titrate immediately with 0.1000N KM_nO_4 to pale pink end point. The KM_nO_4 oxidized the iron to the ferric state.

$$\frac{\text{ml } kMnO_4 \times 0.1N \times 0.05585 \times 2.5 \times 1.4297 \times 100}{\text{weight of the sample}} = \%\ Fe_2O_3$$

5b. If the sample is not high in iron, the iron may be determined by one of the colorimetric methods shown in Standard Methods.

6. Phosphate (P_2O_5 by Molybdate)

Take a 10 ml aliquot of the filtrate of the silica, dilute to 50 ml in a Nessler's tube. Place the solution in a 125 ml

Erlenmeyer flask. Add 1 ml of standard $(NH4)_6MO_7O_{24}$-$4H_2O$ followed by 1 ml of standard 1 amino 2 napthol 4 sulfuric acid solution. Let stand for exactly 10 minutes, transfer to a colorimetric tube and read color transmission on photometer using filter no. 660. Results are read on PO_4 molybdate curve as ppm. PO_4 on the basis of a 50 ml sample and calculated as % P_2O_5:

$$\frac{\text{PPM x 5x .7474 x 100}}{\text{mgms of sample x 4}} = \%\ P_2O_5$$

Note: If acid concentration is high, color development will be decreased, therefore it is wise to run a 5 ml aliquot also. If the acid concentration is high, the 5 ml aliquot will give a greater color development indicating the necessity of diluting out the sample to reduce the high acid concentration.

7. Aluminum Oxide (Al_2O_3)

$$\%R_2O_3 - \%Fe_2O_3 = \%Al_2O_3{}^*$$

* Assuming that there is no titanium, manganese or phosphate in the sample.

8. Calcium Oxide (CaO)

Evaporate the filtrate from the R_2O_3 separation to approximately 200 ml. Using HCL, make the solution slightly acid to the methyl red.

Add 10 ml of a 10% solution of $(NH_4)_2\ C_2O_4$ dropwise with constant stirring. Neutralize with concentrated NH_4OH. Digest on the steam bath for two hours. Filter while hot using a sintered glass crucible. Wash with doubly distilled water. Save filtrate for the MgO determination.

Dissolve the calcium oxylate precipitate by adding hot 6N H_2SO_4 to the crucible 3 times, then washing with doubly distilled water. Heat to 60 to 80°C and titrate immediately with 0.1N $KMnO_4$ to a faint pink color.

$$\frac{\text{ml } KMnO_4 \text{ x 0.0028 x 2.5 x 100}}{\text{weight of sample}} = \%\ CaO$$

9. Magnesium Oxide (MgO)

Use the filtrate from the calcium oxide determination. Add the following: 20 ml of saturated microcosmic salt solution, a few drops of thymol blue indicator and then concentrated NH_4OH to the appearance of a dark bluish-green color. Let stand overnight. Filter the precipitate using an ignited and weighted Gooch crucible. Wash with mg washwater. Ignite at 1000°C, cool, and weigh as $Mg_2P_2O_7$.

$$\frac{\text{wt of ppt x 0.3621 x 2.5 x 100}}{\text{weight of sample}} = \%MgO$$

10. Calcium and magnesium may be determined also by EDTA titration. The filtrate from the R_2O_3 extraction is made up to a 500 ml volume, and the hardness and calcium content determined.
mg/l hardness (as $CaCO_3$) - mg/l Ca (as $CaCO_3$) = mg/l Mg (as $CaCO_3$)

$$\frac{\text{mg/lCa (as}CaCO_3\text{) x 0.07}}{\text{weight of sample}} = \text{\% CaO}$$

$$\frac{\text{mg/lMg (as }CaCO_3\text{) x 0.05}}{\text{weight of sample}} = \text{\% MgO}$$

11. Carbon Dioxide (CO_2)

Refer to pages 355 thru 359 in "Elementary Quantitative Analysis" by Willard and Furman.

12. a. If the analyst has reason to suspect the presence of other elements in the scale, these should be determined by appropriate methods.

b. When a scale analysis is completed the sum of the percentages of each of the constituents should total approximately 100%.

Summary of Development of Standard Test Documents

The work of the Standardization Sub-Committee is continuing. More information is required for recommended sampling procedures for wastes from sedimentation basins and filter washwater. Additional comments and suggestions are required on the tests and procedures that have been submitted, in order to obtain the analytical data needed for the characterization of sludges. Answers are also required on the need for supplemental tests and whether the methodology already described is sufficiently detailed.

The Research Foundation will evaluate additional comments on these proposed documents and remaining areas of research. Correspondence will be coordinated with individuals expert in the treatment of water and the analysis of sludge from water purification and softening facilities.

Introduction to Polymer Evaluation Program

The amount and type of sludge produced at a treatment plant is partially dependent upon the processes utilized and the efficiency of operation. Another approach to the sludge disposal problem is through the use of new coagulants. This view was stated in the report titled "Disposal of Wastes from Water Treatment Plants", and later at the meeting of the Project Advisory Committee.

The use of polyelectrolytes as coagulants in place of alum could represent a new tecnological change that would significantly alter the waste character. The effectiveness of polyelectrolytes as coagulant aids might reduce the quantity of alum utilized in treatment processes. Finally, polyelectrolytes have been shown to effectively act as sludge conditioning agents, making waste sludges more amenable to dewatering.

The Research Foundation has initiated the organization of material which can be utilized in the evaluation of polymers. The extent of progress in this undertaking follows.

Polymer Evaluation Program

The Research Foundation made a literature search of the Journal American Water Works Association to determine if a standard jar testing procedure had been utilized to evaluate polymers as primary coagulants, coagulant aids, and sludge conditioning agents at different water utilities. Four articles were found that suggested possible parameters to be considered in a jar testing program.

A search for additional publications produced an AWWA manual titled "Simplified Procedures for Water Examination - M-12." This manual contains a basic jar testing format and recommendations useful in structuring a polymer evaluation program.

In addition to the literature sources, the Research Foundation utilized the expertise of two water utility operating practice personnel and one university research investigator in preparing the preliminary test documents. The suitability of the basic test documents has been agreed upon by the experts and the Foundation as a good starting point. It is planned to utilize wider experience to conduct an evaluation program which will lead to revision and modifications to these documents.

Seven basic documents have been coordinated to allow the testing of the polymers. These documents are: jar test data sheet; basic data test procedure; procedure to evaluate sludge conditioning agents; sludge conditioner data sheet; filter aid evaluation by means of a filter test leaf; standard column test procedure; and a simplified jar test procedure.

Jar Test Data Sheet

The data required for the polymer evaluation has been limited mainly to physical tests. These tests provide meaningful information and minimize lengthy chemical analyses.

In attempting to correlate the data to the raw water quality, a raw water analysis data sheet will be submitted for the day the polymer was tested.

A settling speed test was included. The settling speed test should provide some indication of how much a polymer primary coagulant or aid will increase the settling rate and compress the sludge when compared to the coagulant presently used. Most of the rapidly settling curves will be exponential in form. Settling data will be recorded and plotted.

The data can be plotted on semi-logarithmic coordinates to give an indication of an exponential settling factor k from the equation:

$$S = C_1 e^{-kt}$$

where
S = settling height
C_1 = initial height of interface
k = time $^{-1}$
t = time

The data sheet for the investigation of polymers as primary coagulants and coagulant aids is illustrated in reduced form. Figure 1, the front of the sheet, contains information on chemical additions to each jar and basic data recorded. This side also contains instructions for the settling speed test. Figure 2, reverse side of the sheet, shows the record of data and plot of the interface level versus the time on cartesian coordinates.

Basic Data Test Procedure

The specification of data procedures will provide a basis for comparison. The parameters on the data sheet are to be determined in the following manner:

Water Temperature (°C):

Temperature measurements should be made in accordance with the specifications outlined in Standard Methods. The temperature of each jar sample should be taken immediately before rapid mixing.

Supernatant Turbidity (JTU):

Turbidity measurements should be made in accordance with Standard Methods or by approved instruments that are used in daily laboratory evaluations. Indicate the method of measuring the turbidity.

pH

The pH measurement should be made in accordance with Standard Methods. The measurement can be made with a commercial pH meter approved for use in daily laboratory evaluations. Indicate the method (pH meter) used to obtain the measurement.

Floc Formation Time:

Reference is made to an article titled "Techniques of Coagulation Testing - Part 1" appearing in the September, 1970, issue of the Journal American Water Works Association. The test for floc formation time is taken from this article. The test follows.

"This is a very simple test in which the time between the coagulant addition and the first appearance of visible floc is recorded. Often,

FIGURE 1

PRIMARY COAGULANTS AND COAGULANT AIDS

Date ______________

Reporting Utility ________________
Location ________________
Raw Water pH ________________

Source of Supply ________________
Official Reporting ________________
Raw Water Turb.(JTU) ________________

CHEMICALS ADDED (mg/1):

Jars	1	2	3	4	5	6
Alum						
Carbon						
Lime						
Soda Ash						
Ferric Sulfate						
Aid (Name)						
BASIC DATA:						
Water Temperature (^0C)						
Supernatant Turb.(JTU)						
Supernatant pH						
Floc Formation Time(min)						
Visual Floc Size						
Supernatant Hard.($CaCO_3$)						

SETTLING SPEED:

1. Observe the results of the testing for jars 1 to 6.
2. Select the best or two best coagulant dosages on the basis of the data.
3. Set up beakers with the same dosages of the best coagulant(s) and the control jar and repeat the jar test procedure.
4. Following slow mixing, measure the height of the solid-liquid interface in centimeters. Record this height at the times indicated on the data sheet provided.
5. Plot the height of the interface versus the time recorded on the graph provided.

(See reverse side of this page for data sheet and graph)

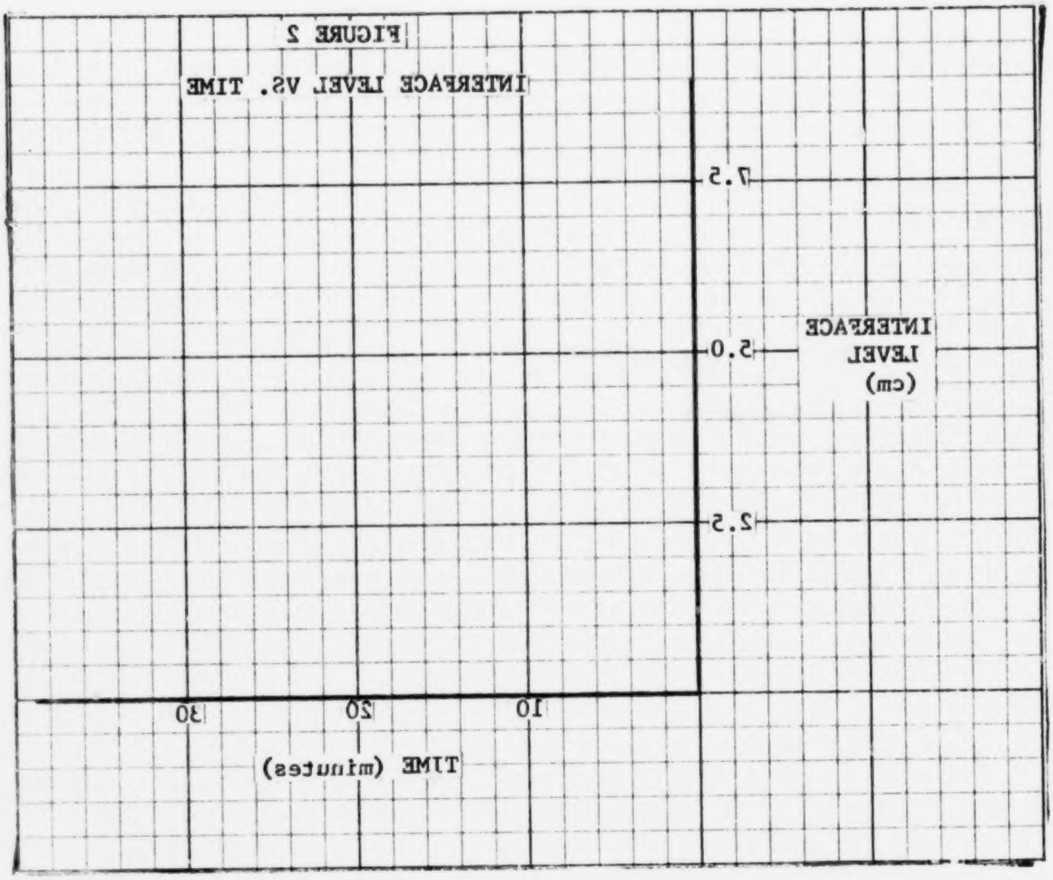


FIGURE 2

INTERFACE LEVEL VS. TIME

TIME (min)	INTERFACE LEVEL (cm)			TIME (min)	INTERFACE LEVEL (cm)		
Jars	____	____	____	Jars	____	____	____
1	____	____	____	10	____	____	____
2	____	____	____	15	____	____	____
3	____	____	____	20	____	____	____
4	____	____	____	25	____	____	____
5	____	____	____	30	____	____	____

Remarks: ____

____

a Tyndall light beam is used to help detect the small initial floc. Even with this aid, the nearly colorless floc particles formed in many instances are difficult to see when first formed and as a result, visual observations are quite qualitative. Also, there is no assurance that the first floc to form will possess the most durable properties in the later stages of the process."

Visual Floc Size:

This test is derived from the same article as the floc formation test. "This test merely consists of an observer qualitatively recording or comparing the flocs as they are formed. Different observers may reach different conclusions about the same suspension. In addition, this technique overlooks the importance of floc strength and density. An attempt to partially quantify the visual evaluations of the floc size has been made by the establishment of the Wilcomb's Floc Index. This approach consists of relating visual characteristics of floc formation and settling to an index number from 0 to 10. High index numbers represent relatively large floc particles with good settling properties."

A modification of this test appears in the "Simplified Jar Test Procedure." This test uses the size of the control jar floc as unity and then requires an estimation of the floc size in the remaining jars in relation to this unity floc. For example, a floc size appearing twice as large as that in a control jar has a visual floc size of 2.

Supernatant Hardness:

Hardness can run on the same sample used for supernatant turbidity. The hardness test should be performed in accordance with Standard Methods.

Simplified Jar Test Procedure:

A standard jar test procedure is contained within AWWA manual M-12 titled "Simplified Procedures for Water Examination." A standard testing plan is required to provide a basis for the comparison of polymers as primary coagulants and for coagulation aids in a centrally directed program. The purpose of this phase of the Research Foundation information resource program is to determine the suitability of polymers in either reducing the total amount of sludge or concentrating the waste volume of sludge generated at water treatment plants.

The following procedure will be used to initiate testing. This procedure combines the use of information established by AWWA in its publication, and the modifications and suggestions as determined by water utility experts and the Foundation.

Purpose of Jar Tests

Manual M-12 states "the jar tests are designed to show the nature and extent of the chemical treatment which will prove effective in the full scale plant. Many of the chemicals added to a water supply can be evaluated on a laboratory scale by means of jar tests. Among the most important of these chemicals are coagulants, coagulant aids, alkaline compounds, softening chemicals, and activated carbon for taste and odor removal. The test also permits the appraisal of the relative merits of the aluminum and iron coagulants, or in conjunction with such coagulant aids as activated silica, polyelectrolytes, clays, stone dust, activated carbon, settled sludge, lime, and soda ash."

Warning

The manual also notes several considerations that may affect the outcome of jar testing. It states "even the smallest detail may have an important influence on the result of a jar test. Therefore, all samples in a series of tests should be handled as nearly alike as possible. The purpose of the test will determine such experimental conditions such as flocculation and settling intervals. Since temperature plays an important role in coagulation, the raw water samples should be collected and measured only after all other preparations have been made, in order to reduce the effect that room temperature might have on the sample."

Apparatus

The following equipment will be utilized to evaluate the polymers:

1. A variable speed (0 to 0 to 100 revolutions per minute) stirring machine with three to six paddles (each paddle size 1" to 3").

2. A floc illumination device to be located under the base of the laboratory stirrer. This illuminator will be used to determine both the floc formation time and the visual floc size included on the data sheet.

3. Six standard beakers of 1500 - ml capacity (approximately 4.5 inches diameter by 6.4 inches high). These pyrex beakers will be required as reaction vessels.

4. A plastic pail or similar sample collection container with a capacity in excess of 2 gallons will be required. The sample should be homogeneous for each complete jar test run.

5. One 1,000 ml graduated cylinder.

6. Measuring pipets of 1, 5, and 10 ml, graduated in 0.1 ml steps, for dosing samples rapidly with the necessary coagulants, suspensions, and solutions. These pipets should be thoroughly rinsed with distilled water after using to prevent the caking of solutions.

7. A 100 ml pipet for withdrawing the coagulated softened water supernatant sample for turbidity and hardness determinations.

8. Instrumentation for the monitoring of water temperature, turbidity, floc formation time, and hardness (for softening plants) is required.

9. Special apparatus for softening test:

   a. Filter Funnel
   b. Filter paper of medium retentiveness. Either Whatman No. 40 or Schleicher & Shull No. 589 is satisfactory.

Dosing Solutions and Suspensions

The importance of simulating plant conditions as closely as possible cannot be overemphasized. The manual states "dosing solutions or suspensions should be prepared from the stock materials actually used in plant treatment. Distilled water used for the preparation of lime suspensions should be boiled for 15 minutes to expel the carbon dioxide and then cooled to room temperature before the lime is added."

Details are presented in AWWA Manual M-12 on the preparation of coagulant dosing solutions and suspensions; preparation of an activated silica dosing solution; and preparation of an activated carbon dosing solution.

In testing polymeric coagulants or coagulant aids supplied by cooperating polymer manufacturers, solutions of these products will be prepared in accordance with manufacturer specifications.

The frequency of preparing dosing solutions and suspensions is explained. These instructions will be used to insure uniform testing.

Reagents

The reagents needed in determining turbidity and hardness can be found in Standard Methods.

Test Procedure for Coagulant Aid Treatment

The addition of alkaline agents, clay suspensions, or activated silica are covered under number 14 in this format. When the water contains natural color, alum should be added before other agents or coagulant aids.

Items 1 to 6 and 14 have been taken from Manual M-12. The remaining items have been developed through the coordination of the Foundation.

1. Rinse six 1,500 ml beakers with tap water and let the beakers drain for a few minutes in an upside - down position. Beakers that have had several days of use should be scrubbed inside

and out with a brush and a household dishwashing detergent, finishing with a thorough rinse of tap water.

2. Clean the stirring machine paddles with a damp cloth.

3. Collect a sample of raw water and complete Steps 4 through 8 within 20 minutes. Throw away the sample and collect a fresh sample if the work must be interrupted during this critical stage. Otherwise, the settling of high turbidity and an increase in the sample temperature from the heat of the laboratory may cause erroneous results.

4. Stand the beakers right side up and pour more than 1 liter of raw water into each one.

5. Taking one beaker at a time, pour some of the raw water back and forth between the beaker and a 1-liter graduated cylinder. Finally, fill the graduated cylinder to the 1-liter mark, and discard the excess raw water in the beaker. Return the measured 1-liter sample to the beaker.

6. Place all the beakers containing the measured 1-liter samples on the stirring machine.

7. Lower the stirring paddles into the beakers, start the stirring machine and operate it at 100 r.p.m.

8. With a measuring pipet, add the same dosages of the coagulant solution that is used in your treatment facility to the six test beakers, at nearly the same time as possible. Record the time required to produce a visible floc on the data sheet.

9. Apply the polymeric coagulant aid at dosages of 0.05, 0.1, 0.15, 0.2 ppm, etc. to the five above beakers at 100 rpm for three minutes. The sixth beaker should be a control jar to which no coagulant aid is to be added. With a proper series, the beakers should show good to excellent coagulation results depending on the control jar. It may be necessary to repeat the jar test to ascertain the proper series of doses for the desired results.

10. Reduce the stirring speed over the next 30 seconds to 40 rpm, and continue stirring at this speed for a 15 minute period.

11. Stop the stirring machine and allow the samples to settle for 5 minutes. Observe the floc sizes in each jar. Use the control jar floc size as unity. Then visually compare the size of the remaining floc particles in jars 1 to 5 under visual floc size, an example, if the floc in jar 5 appears twice as large as the floc in control jar 6, record 2 for jar 5 under visual floc size on the data sheet.

12. Using a 100 ml pipet, withdraw a sample for turbidity measurement one inch below the surface of each beaker.

13. a. Determine the turbidity of the coagulated sample in accordance with Standard Methods or approved turbidimeters. Record this on the data sheet.
    b. Using the sample from the turbidity measurement, determine the supernatant pH and record the pH on the data sheet.

14. a. Add alkaline agents if the plant normally adds these agents.

    b. Addition of clay suspensions. Where clay is used to improve the coagulation of low turbidity water, add a well-shaken clay, kaolin or stone dust dosing suspension (prepared in accordance with dosing solution and suspensions specifications) just before the coagulant. Then follow procedures 1 to 13.

    c. Addition of activated silica. Where activated silica is employed as a coagulant aid, use the activated silica sol in amounts to give a dosage range of 1 to 7 mg/l. On the average, activated silica dosages of 2 to 5 mg/l yield satisfactory results. Determine by experiment whether the activated silica sol should be added before or after the coagulant for best results. Then follow the procedure in items 1 to 13.

Test Procedure for Lime-Soda Ash Softening Treatment

1. Determine the Hardness according to Standard Methods.

2. Follow steps 1 through 6 under Procedure for Coagulant Aid Treatment.

3. Prepare each jar with the lime or lime-soda ash dosages required to soften the water in the actual plant.

4. Lower the stirring paddles into the beakers, start the stirring machine and operate it for one minute at a speed of 80 revolutions per minute.

5. Select a range of coagulant aid dosages so that the first beaker will represent undertreatment and the fifth beaker will represent overtreatment. The sixth beaker should be a control jar to which no coagulant aid is to be added.

6. Reduce the stirring speed over the next 30 seconds to 30 revolutions per minute, and continue stirring at the speed for 15 minutes.

7. Stop the stirring machine and allow the sample to settle for 5 minutes.

8. Observe the floc sizes in each jar. Use the control jar floc size as unity. Then visually compare the size of the remaining floc particles in jars 1 to 5 to the control jar. As an example, if the floc in jar 5 appears twice as large as the floc in control jar 6, record 2 for jar 5 under visual floc size on the data sheet.

9. Using a 100 ml pipet, withdraw adequate samples for turbidity, pH and hardness measurements one inch below the surface of each beaker.

10. a. Determine the turbidity of the softened sample in accordance with Standard Methods or approved turbidmeters. Record this on the data sheet.

    b. Measure the hardness of the supernatant sample and record on the data sheet.

    c. Determine the supernatant pH and record the pH on the data sheet.

Test Procedure Involving Activated Carbon Treatment

Use the carbon dosage required in the treatment plant. Add this reagent to each jar and follow the same coagulation and softening techniques described herein.

Test Procedure for Primary Coagulant (Polymer) Treatment

1. Follow steps 1 through 6 under Procedure for Coagulant Aid Treatment.

2. Apply dosages of 0.4, 0.8, 1.2, 1.6 ppm, etc. to five 1 liter water samples with mixer set at 100 rpm for 1-3 minutes for initial floc formation. The sixth jar should be a control and contain the primary coagulant, in the appropriate dosage, used in the full scale plant. Record the floc formation time on the data sheet.

3. Reduce the mixer speed to 40 rpm for the remainder of the 15 minute period.

4. Discontinue stirring, remove beakers and start timing immediately for 5 minute settling time.

5. Siphon a sample for turbidity and pH measurements one inch below the surface of each beaker at the end of the 5 minute settling period. Record this data.

6. Compare the results to that of the present primary coagulant (jar 6).

Sludge Conditioning

The utility of polymers to enhance the dewatering characteristics of purification and softening plant sludges is an important consideration. Polymers may demonstrate applicability as sludge conditioning agents by reducing total waste volumes prior to additional treatment or ultimate disposal.

A method to evaluate polymers as sludge conditioning agents, titled "Procedure to Evaluate Sludge Conditioning Agents"; and a "Sludge Conditioner Data Sheet", were developed through the efforts of the water utility experts and the coordination of the Research Foundation. Figure 3 illustrates the data to be collected in this evaluation. A procedure titled "Filter Aid Evaluation by Means of Filter Test Leaf", published by the Nalco Chemical Company will also be used in the program.

Procedure to Evaluate Sludge Conditioning Agents

1. Place 1000 ml of well agitated sludge in each of six 1500 ml beakers or suitable jar test equipment.
2. While stirring at 25 revolutions per minute, add polymer to five beakers. Each of these five beakers should have a different polymer dosage. One beaker will have no addition of polymer and will function as a control.
3. Stir the beakers at 25 revolutions per minute for two minutes, then stop the stirrer and remove the paddles.
4. Measure the height of the interface between sludge and supernatant liquid in centimeters at 5 minute intervals and record up to 30 minutes.
5. Determine the turbidity and pH of the supernatant.
6. Insert filter leaf equipment (35 mesh Teflon cloth) ½" above the bottom of the beaker and, using a vacuum of 20 inches of mercury, filter for 2 minutes.
7. Remove solids from filter leaf carefully and record weight.
8. Dry above solids for one hour at 105°C and record weight.
9. If necessary, repeat the above procedure using smaller incremental dosages of polymer over the most favorable range.

Calculations

$$\frac{\text{Wet Solids (7)} - \text{Dry Solids (8)} \times 100}{\text{Wet Solids (7)}} = \text{\% moisture}$$

FIGURE 3

SLUDGE CONDITIONER DATA SHEET

Reporting Utility ______________________ Date ____________________

Type Sludge ______________________ Sample Source ____________

Polymer Tested ______________________ Analyst ________________

Jars	1	2	3	4	5	6
CHEMICALS ADDED (mg/l):						
1.______________	_____	_____	_____	_____	_____	_____
2.______________	_____	_____	_____	_____	_____	_____
3.______________	_____	_____	_____	_____	_____	_____
BASIC DATA:						
Water Temperature (^{0}C)	_____	_____	_____	_____	_____	_____
Interface (cm)	_____	_____	_____	_____	_____	_____
5 min.	_____	_____	_____	_____	_____	_____
10 min.	_____	_____	_____	_____	_____	_____
15 min.	_____	_____	_____	_____	_____	_____
20 min.	_____	_____	_____	_____	_____	_____
25 min.	_____	_____	_____	_____	_____	_____
30 min.	_____	_____	_____	_____	_____	_____
Wet Solids (gr)	_____	_____	_____	_____	_____	_____
Dry Solids (gr)	_____	_____	_____	_____	_____	_____
% Moisture	_____	_____	_____	_____	_____	_____
Supernatant Turb(JTU)	_____	_____	_____	_____	_____	_____
Supernatant pH	_____	_____	_____	_____	_____	_____

SLUDGE ANALYSIS AND REMARKS:

Filter Aid Evaluation by Means of Filter Test Leaf

The Nalco publication states "a laboratory filter test leaf can be used to determine the filtration aid chemical or chemicals necessary, approximate dosages, order of addition in the case of more than one chemical, the amount of agitation necessary in conditioning the sludge and the filtration cycle (time), to obtain optimum sludge dewatering."

The apparatus required and the test procedure is detailed. Illustrations and a sample calculation are provided.

Standard Filter Column Test Procedure

The filter column test may be utilized to further substantiate the floc settling rate as determined by turbidity measurements in the jar test. The filter column test also aids in determining floc strength and filterability. A dense, rapidly-settling floc should resist pull-through at filtration rates of 6 gallons per minute per square foot, and headlosses of 6 feet and higher. Low turbidities in the filter effluent at high rates and headlosses indicate a strong floc. Comparatively long filter cycles and low turbidities indicate a highly filterable floc. This test is useful for the evaluation of filter aids.

Evaluation of Filter Aids

Evaluation of a polymer to determine its suitability for use as a filter aid requires two separate procedures. The first procedure involves the "Simplified Jar Test Procedure" to determine the effectiveness of the polymer in producing a good floc (as a primary coagulant) or the development of a rapidly settling floc (as a coagulant aid). The effectiveness of the polymer is determined by examining the basic data of the jar test.

If the jar tests show a polymer to be effective in producing a good floc and/or promoting a rapidly settling floc at economical dosages, then the polymer should be evaluated as a filter aid. This evaluation is accomplished through the "Standard Filter Column Test Procedure."

Procedure

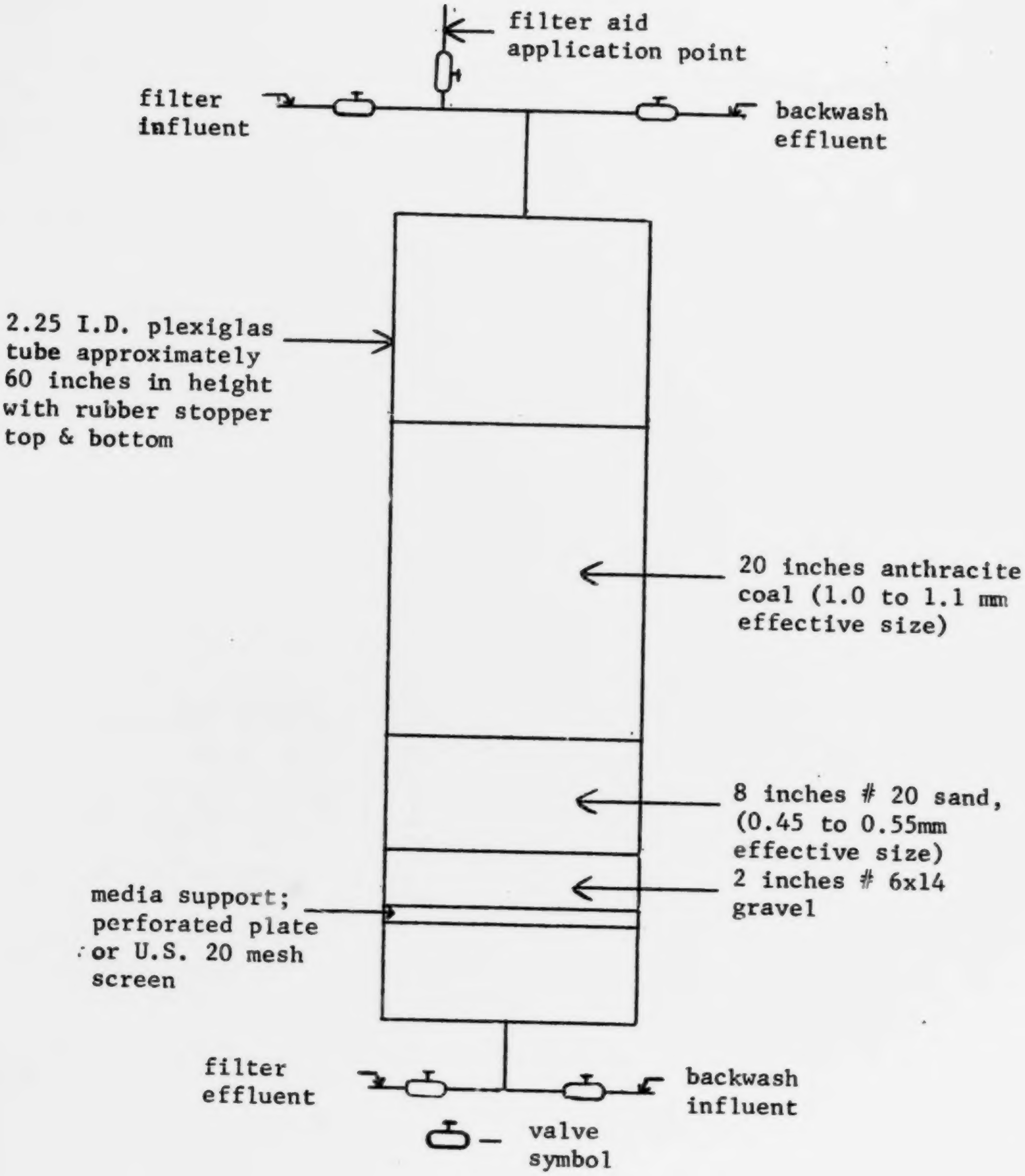
Efficient performance of cationic, anionic, or nonionic polymers as filter aids requires a considerably lower dosage than when polymers are used as primary coagulants or coagulant aids. Dosage requirements as filter aids range from 10 to 100 parts per billion (ppb).

1. The design of the filter column and specifications are shown in Figure 4. The filter media may be of the type shown, or the sand and coal may be replaced by 20 inches of #20 sand.

2. Polymers to be tested should be prepared at a solution concentration such that the volume applied is approximately ten percent of the total

FIGURE 4

EQUIPMENT FOR STANDARD FILTER COLUMN TEST


filter aid application point
filter influent
backwash effluent
2.25 I.D. plexiglas tube approximately 60 inches in height with rubber stopper top & bottom
20 inches anthracite coal (1.0 to 1.1 mm effective size)
8 inches # 20 sand, (0.45 to 0.55mm effective size)
2 inches # 6x14 gravel
media support; perforated plate or U.S. 20 mesh screen
filter effluent
backwash influent
valve symbol

volume being filtered. This insures good mixing of filter aid with the water being filtered. Dilute solutions of polymers are not stable; therefore, the polymer feed solution must be prepared fresh daily.

3. Filter column tests should be performed at filtration rates of 6 to 10 gallons per minute per square foot.

Example:

A filter rate of 6 gallons per minute per square foot equals 627 ml per minute in a 2.25 inch inside diameter column. The volume of filter aid required is 60 ml per minute. To feed 30 ppb, a filter aid solution concentration of 0.31 mg per liter is needed.

4. The filter column should be backwashed for a period of 3 to 5 minutes at approximately 2500 ml per minute prior to each test.

5. A filter column test may be considered complete when turbidity values determined each 15 minutes show that maximum filter efficiency has been attained; that is, when the turbidity of the filtered water remains at a minimum level. This level of turbidity is the measure of the performance of the filter aid.

The results of the filter column test will be recorded on the "Filter Column Data Sheet." Figure 5 illustrates the data to be recorded in this evaluation.

A Cooperative Program

The cooperation of water utilities and suppliers of polymer products is essential for the development of polymer evaluation methodology. Several chemical suppliers were informed of the Foundation's centrally directed program to organize, coordinate, and disseminate information on new or modified water treatment technology. Each supplier was informed of the Foundation's plans to publicize the applicability of polymers, approved by the United States Public Health Service, that have utility in the water utility industry.

Three types of polymers are of importance:

1. Primary coagulants, capable of replacing alum or ferric salts and reducing total waste volume;

2. Coagulation aids, capable of partially reducing alum dosages, reducing waste volumes and improving treatment efficiency; and

3. Sludge conditioning agents, capable of enhancing sludge settling characteristics and sludge dewatering ability.

A list titled "Approved Chemicals Available for Treatment and Disposal" was sent to each supplier for review.

FIGURE 5

FILTER COLUMN DATA SHEET

Sample No. ____________________
Sample Source ____________________
Sample Collection Date ______ Sampler ____________
Testing Laboratory ____________________
Testing Date ______ Analyst ____________

Sample Quality Data

pH ____________
Temperature (°C) ____________
Turbidity (JTU) ____________
TDS (ppm) ____________

TEST DATA

	Filter Aid				FILTER EFFLUENT					
					Turbidities (JTU) Time after start of filter run (min)				Minimum Turbidity	
Test No.	*Name & Type	Dosage (ppm)	Filter Rate gpm/sq ft	Filter Influent Turbidity (JTU)	5	10	20	30	(JTU)	Time after start (min)
1.										
2.										
3.										
4.										
5.										
6.										

Remarks:

---

* After name, designate type in parenthesis; (=) for cationic; (-) for anionic; (0) for nonionic.

Approved Chemicals Available for Treatment and Disposal

The purpose of this phase of the Foundation's study is to evaluate USPHS approved chemicals for effectiveness as primary coagulants, coagulant aids, and sludge conditioning agents. The cooperation of chemical suppliers was requested in providing the following information and concerning each available product.

Technical Data:

A. Product Description

B. Advantages

C. Physical and Chemical Properties

D. Applications

E. How It Works

F. How to Use Product

G. Methods of Feeding

H. Packing and Shipping Information

I. Laboratory Test Procedure

J. Range of Dosages

Samples:

The following request was directed to chemical suppliers:

"The Research Foundation would like to be advised of the availability of free samples. These samples would be tested at water treatment plants of the Foundation's choice in accordance with your suggested applications."

"The plants we choose will represent a broad geographic area and have a variety of raw water and waste characteristics. The testing personnel will be experienced. The laboratory equipment required will be available."

Publicity:

"The utility of each chemical will be reported to the Research Foundation. The staff will then prepare a paper about the tested polymers. The approved paper will be published by the Research Foundation."

Acknowledgement:

"A. Please acknowledge our letter to let us know if your organization is interested in such a program."

"B. If your organization wishes to participate, please explain the extent of cooperation your organization can provide."

Summary - Polymer Evaluation Program

This program is designed to accomplish several purposes. Through the use of the standard procedures to evaluate polymers as primary coagulants and coagulation aids, the Research Foundation and participating water utilities can systematically:

1. Define the type of data that illustrates the effectiveness of primary coagulants and/or coagulation aid products. The methodology will provide a means of selecting various polymer products that warrant further investigation.

2. Produce a data sheet that has applicability in evaluating polymers at both purification and softening plants.

3. Publicize the experience of a standard testing program, noting the revisions in the procedures, and promote the findings for the benefit of the water utility industry.

Through the use of the three documents to evaluate polymers as conditioning agents for water treatment sludges, the Research Foundation and participating water utilities can:

1. Determine the ability of polymers to concentrate water treatment plant wastes and make the wastes more easily dewaterable.

2. Determine the order of magnitude of final waste volumes that can be expected due to the increase in dewatering ability of the concentrated wastes.

3. Relate this conditioning to the use of polymers as a treatment before landfill disposal or as a step in a by-product recovery operation.

4. Publicize this waste conditioning procedure for treating sludges.

Through the use of the documents to evaluate polymers as filter aids, the Research Foundation and participating water utilities can:

1. Define the data and procedures that are useful in illustrating the effectiveness of filter aids.

2. Publicize the experience of the standard filter test procedure for the benefit of the water utility industry.

It is realized that this polymer testing program is restricted by several factors, due to the degree of standardization specified. The importance of several parameters will be evaluated in the program: the value and significance of floc formation time, and a subjective visual floc size test, the ability to read a representative interface in the settling speed test, and standard speeds and times of mixing. The testing program may require further modification before specific products can be adapted for full scale use .

Response from Chemical Suppliers

Each chemical supplier acknowledging interest in participating in this program received copies of the testing procedures. The suppliers were notified that a copy of the raw water characteristics of perhaps ten participating water utilities would be forwarded to them. The Foundation has enlisted four water utilities to date. The treatment plants are not named. The special instructions of each supplier relating to each product will be incorporated into the test procedure for that product. Examples are: recommended dosage range; method of application (dry, liquid solution); applicability of product (primary coagulant, coagulant aid, sludge conditioning agent); frequency of mixing dosing solutions; and other appropriate suggestions.

The evaluation of this polymer testing program by water utilities is still to be initiated. The Research Foundation anticipates that the experience and constructive comments received will be utilized to modify and improve the basic test documents. Such a testing program has never before been conducted, and the program planned should be of mutual benefit to the water utility industry and manufacturers of chemical supplies.

Manufacturers of Equipment

Many new or modified sludge treatment processes will require the use of equipment that is principally designed for or adapted to water utility wastes. Several water and waste water trade publications include yearly product guides to define the availability of equipment from various manufacturers.

The Research Foundation recognized that the identification of sludge processing equipment and its relation to water treatment plant wastes will be a useful reference. The accumulation and publication of information on this equipment can provide a guide for water utilities to use in individual plant studies or design.

Three trade publications were used to provide a list of manufacturers supplying equipment that will have potential application in processing water treatment plant wastes. These publications were:

1. Industrial Water Engineering Buyer's Guide - 1971
2. Water and Sewage Works, Reference No. 1970
3. 1970 - 1971 AWWA Yearbook

The types of equipment that the Research Foundation identified includes: centrifugation, deep-well disposal, dewatering, pressure and vacuum filtration, incineration, sludge concentrating, and sludge processing equipment.

Over one hundred equipment manufacturers have been contacted. The manufacturers received background information on the nature of the information resource program. The Research Foundation plans the publication of a guide to such equipment, describing its applicability for handling water treatment plant wastes.

A form titled "Equipment Available for Treatment and Disposal" was prepared for review by the manufacturers.

Equipment Available for Treatment and Disposal

Specifications for Reporting:

Please provide the following information for each product your organization has available for water treatment plant waste dewatering, recovery, and disposal operations. This must be limited to two 8½x11 pages.

1. Graphic Illustration - Provide either a photo or drawing of waste treatment equipment, indicating the physical dimensions of the treatment unit (or units). If a specific process has been developed which comprises a series of units, also provide a separate flow diagram illustrating the sequence of operations beginning with waste influent, and ending with waste concentrate and supernatant disposal.

2. Operational Capabilities - Provide a general description of the basic operation of the waste treatment device indicating the following items:

    A. Specific applications of the unit. For example, what type of material can this device handle successfully? Is it more suited to alum, lime, or iron - manganese sludges? What concentrations of waste can the system handle? Exlain how this unit is applicable and under what conditions it will optimally operate.

    B. Indicate the type of results one may expect if this device is utilized. For instance, "this unit can take 4% alum sludge and produce a cake of 35% solids and a filtrate with 20 ppm suspended solids". Similarily, indicate estimated results on other water plant wastes as determined by pilot or plant scale operation of the treatment device.

    C. Hydraulic Capacity - Provide information on the range of hydraulic capacities that the unit can handle. Indicate whether the device is more suitable for low range or high range flows. List special hydraulic considerations, as flushing sprays for cleaning the unit. As an example, "the ABC unit produced a 10% waste concentrate that was 15% of the waste influent flow."

    D. Note specific locations where the unit has been, is being, or will be used to treat water treatment plant wastes.

3. Manufacturer Contact - The equipment publicity is expected to produce further inquiries among the readers of our Newsletter. To facilitate the handling of these inquiries the following items will be published.

    A. Exact name of specific equipment.

    B. Manufacturer's name, address, and individual to be contacted.

The Research Foundation anticipates that those equipment manufacturers that have not undertaken research and development of sludge handling equipment for water utility wastes will realize the need for new processes and equipment.

Manufacturers of lagoon covers and linings were identified using the same trade publications. These products may be useful in the lining of evaporation ponds for the treatment concentrated brine solutions from ion-exchange softening facilities and desalination plants.

Responses to this survey have been received, and the accumulation and inventory process of applicable sludge handling equipment is a continuing operation. Interested manufacturers transmit material on products they market in accordance with the report specifications previously outlined.

The need for effective and economical sludge treatment equipment cannot be overemphasized. The importance of developing equipment to handle the water utility industry's wastes is becoming increasingly important, as a result of new and more demanding pollution control legislation. As an additional clearing-house function, the Research Foundation can publicize and promote the application of appropriate equipment.

SECTION X

REFERENCE ABSTRACTS

One function of the AWWA Research Foundation, as a central information resource, is to abstract and index all available literature on the treatment and disposal of wastes from water treatment plants. The abstracts are prepared in accordance with the specifications of the Water Resources Science Information Center (WRSIC). WRSIC reviews, edits, and stores abstracts into a computerized system for future retrieval.

The Research Foundation selected and reviewed technical articles from a variety of sources. These sources include: articles identified through literature searches; articles transmitted to the staff from engineering, research, and operating practice advisory group members; papers delivered at national and local AWWA section meetings; and articles listed in the bibliography of the report titled "Disposal of Wastes from Water Treatment Plants."

A series of reference abstracts is presented on the following pages. These abstracts are capsule summaries of technical articles on water plant waste treatment. Several of these abstracts will be of historic value. All provide references to the development of pollution control technology.

Kelly, Earl M., "Discussion of Reclamation and Re-use of Lime in Water Softening," AWWA JOURNAL, 31, No.4 pp 671-675 (1939).

Key Words: Sludge treatment, Lime recovery, Lime-soda ash softening

Manufacturers producing caustic soda by the lime-soda ash process employed calcining to reclaim calcium oxide from the waste sludge. The Stauffer Chemical Company reclaims 20 tons/day of calcium oxide using clarification, vacuum filtration, calcination, classification, and slaking processes in a simply staffed operation. The raw water chemical nature and treatment utilized restrict the re-use. Magnesium and inert material must be eliminated to optimize the amount of calcium oxide in the calcined product. The pilot study illustrates the success of the Lykkens-Estabrook process and uncovered operational problems to be corrected. The use of ferrous sulphate as a coagulant increased filter rates from 68 to 194 pounds /ft^2 /day. The filter cake contained fine calcium carbonate and magnesium hydroxide crystals and was too coarse for good flocculation or filtration. Filtration rates increase with heating and thickening of the sludge according to laboratory studies. The coagulant can be eliminated. Sludge carbonation increases filterability. Suggestions are made for future study on calcination and slaking.

Hoover, C.P., "Discussion of Reclamation and Re-use of Lime in Water Softening, "AWWA JOURNAL, 31, No.4 pp 675-679 (1939).

Key Words: Sludge disposal, Lime-recovery, Lime-soda ash softening

Lime recovery reduces the cost of lime and sludge handling and generates carbon dioxide for recarbonation in the softening facility. The process has not been adopted for five reasons. Large plants located near waterways discharge their wastes into waterways. Plants, softening river supplies of rapidly changing physical-chemical characteristics, would require intermittent calcining operation and mud-lime separation. The problem of magnesium build-up has only recently been solved. Multiple-hearth furnaces are now available for calcining. Small communities are not interested in new procedures. Planned reclamation activities at the Columbus, Ohio plant in 1914 were curtailed due to various construction and lime cost changes and water quality changes. Laboratory studies show that magnesium hydroxide aids settling. Lime can be utilized as a coagulant for vacuum filtration. At Oklahoma City, provisions are made to return lime sludge to the lime slaker for use in slaking the quicklime. The mixture is fed to the mixing basins. Sludge disposal methods include discharge to streams, lagooning, and reclamation by burning.

Gordon, C.W., "Calcining Sludge from a Water Softening Plant," AWWA JOURNAL, 36 No.11, pp 1176-1177 (1944).

Key Words: Water softening, Flash drying, Calcination

Details are provided on a flash drying system that prepares calcium carbonate sludge for marketing or calcining at two water softening installations. The advantages of this two stage counterflow gas drier are low gas discharge temperatures and the minimization of particulate emissions in the stack gas. Before drying, the carbonate sludge is centrifuged to a 60% solids consistency and conditioned with the previously dried material. Operating parameters and product characteristics are described for the process. The dried calcium carbonate contains 0.5% moisture and can be bagged for marketing or calcined. The calcination system employed at the Marshalltown Water Works is evaluated in relation to the limitations of the water plant operating requirements. These limitations include intermittent operation, ability to produce calcium carbonate, freedom from dust nuisance, maximum thermal efficiency, minimum building space, and adaptability to plant capacity variations.

Hoover, Charles P., "Recovery of Spent Lime at the Columbus Water Softening and Purification Works," AWWA JOURNAL, 3, No. 4, pp 889-896 (1916).

Key Words: Sludge treatment, Lime recovery, Lime-soda ash softening

The release of calcium carbonate sludge to the Scioto River during low flow in the summer months created sludge deposits and legal problems between Columbus and riparian property owners. Maximum sludge production occurs in the summer with maximum river hardness, amplifying the problem. No objection to discharging sludge to the river exists in the fall and winter months when the stream is muddy. The proposed recovery system includes sludge thickening, suction filtering of the continuous type, and rotary kiln burning. Construction details of the furnace are provided. Operating and cost data are presented for the calcium oxide product. The sludge treatment facilities will process lime-soda ash softening sludge and limestone from a nearby quarry alternately for six month durations. A description of the suction filter is given. The settleability of the sludge, build-up of impurities, replenishment of lime, disposal of extra lime and planned additions to the existing plant are discussed.

Sperry, W.A., "The Lime-Softening of Water and the Use of the Sludges as an Aid Thereto," AWWA JOURNAL, 6, No. 2, pp 215-229 (1919).

Key Words: Water softening, Sludge recirculation

The lime-softening process contains several variables that must be considered in producing a stable water. Among these parameters are the residual hardness, colloidal magnesium structure, reaction temperature, reaction time, lime requirements, and coagulant addition. These parameters must be balanced to eliminate filter sand incrustation, lime damage to water meters, coating of service mains, gates, and valves, and scaling of hot water, gas, and furnace heaters. A water softening method that compensated for insufficient settling basins and could eliminate distribution system problems without increasing the use of an alum coagulant was considered for Grand Rapids. Sludge recirculation was tested to remove colloids, save alum, and stabilize the water. Laboratory results on contact time, recirculated sludge volume, coagulant addition, and yearly effectiveness are presented. This study enumerates advantages and disadvantages of plant-scale sludge recirculation testing. Further testing was suggested after these preliminary investigations.

Aultman, W.W., "Reclamation and Re-use of Lime in Water Softening," AWWA JOURNAL, 31, No. 4, pp 640-671 (1939).

Key Words: Sludge treatment, Lime recalcining, Available lime

This report illustrates the economic benefits of reclaiming calcium oxide at a lime-soda ash softening installation in Boulder City, Nevada. The process water is Colorado River water, high in magnesium content. The Lykken-Estabrook process was investigated because this method eliminates increased magnesium content in the reclaimed lime. A predominantly calcium carbonate sludge is pumped to a vacuum filter for dewatering. The filter cake is fed to a multiple-hearth furnace for calcining. Operation and construction details are provided for the furnace and vacuum filter and for the chemical feeding and slaking, flocculation and clarification equipment. The percent of recovery, defined as the available lime to total calcium (CaO), averaged above 90 percent. Data are presented for a gravimetric analysis of a composite calcined lime product. Fuel and power consumption requirements are prepared for the experimental furnace. The test program is summarized. The direct reuse of the reclaimed lime is not suitable with this water.

Pederson, H.V. , "Calcining Sludge from a Softening Plant," AWWA JOURNAL, 36, No. 11, pp 1170-1175 (1944).

Key Words: Water softening, Calcining, Stationary flash type calcining furnace

This study describes the trial and error construction of a stationary flash type calcining furnace and the utility of the recovered calcium oxide at a water softening installation. Calcining experimentation was initiated due to a poor market demand for dried calcium carbonate. Problems associated with sludge characteristics and furnace design are discussed. A system that handles 700 pounds (dry carbonate) per hour at a 2000° F initial combustion temperature was developed after eight furnace modifications. Carbonate sludge, withdrawn from the clarifiers, is pumped to a storage tank. The sludge is gravity fed to a Bird centrifuge for dewatering. The concentrated sludge is flash dried and lifted to a cyclone from which it is screw fed to the combustion chamber. Five tons of calcined lime were produced and a plant scale study initiated. Sludge cake impurities were less than 15% based on thirty days operation with calcined lime. Operating data and benefits for reclaimed lime are discussed.

Nelson, F.G., "Recalcination of Water Softening Sludge," AWWA JOURNAL, 36, No.11, pp 1178-1184 (1944).

Key Words: Calcium carbonate, Calcining

This study shows that the recovery of lime from a partially dewatered calcium carbonate sludge can be economical if the magnesium content of the recycled product is controlled. A correlation between the settling rate and the concentration of a calcium carbonate sludge is suggested. Four factors affecting the settling rates of calcium hydrates are presented. Operating data on the dewatering of a calcium carbonate sludge at the Findlay, Ohio plant by a Bird continuous centrifuge are listed in graphical and tabular form. The parameters investigated include solid feed rates, cake moisture, cake recovery, temperature, and power considerations. The centrifugation process can produce a 500 pound per hour (dry solids) cake of 61% solids. The recovery was 75% of the feed solids. The magnesium content was reduced in the recovered cake. Higher solids capacities and recoveries are possible with carbonated sludges. Data on centrifuged softening sludges are presented for the Marshalltown, Iowa and Wright Aeronautical Corporation softening facilities.

Sheen, R.T., and Lammers, H.B., "Recovery of Calcium Carbonate or Lime from Water Softening Sludges," AWWA JOURNAL, 36, No.11, pp 1145-1169 (1944).

Key Words: Calcium carbonate, Water Softening, Sludge disposal, Lime recovery

This study describes the development of two industrial water supply systems including sludge treatment processes and economics. Detailed process descriptions are presented for the selective calcium softening installation of the Wright Aeronautical Corporation. Data are tabulated for the design parameters used for the softening basin, chemical feeders, filters, recarbonation system, and chemical unloading and storage facilities. Cost comparisons show the advantages of calcium carbonate production to lime recovery. A flow diagram illustrates the calcium carbonate drying sequence. The sequence consists of thickening, centrifugation, and flash drying. A Bird centrifuge with a capacity of 4000 to 6000 pounds (dry solids) per hour is used. The product quality including market price, color comparisons, particle size, and purity is discussed. A process description and flow diagram are provided for the selective calcium softening installation of the Columbia Steel Corporation. Economic considerations of lime reclamation at this facility are tabulated. The advantages and disadvantages of the wedge furnace and rotary kiln calcination units are discussed.

AWWA Committee Report, "Disposal of Water Purification anf Softening Plant Wastes, " AWWA JOURNAL, 39, No.12, pp 1211-1223 (1947).

Key Words: Lagoons, Evaporation, Brine Disposal, Lime-soda ash softening, sodium zeolite softeners

The purpose of this report is to review the methods and practices utilized to handle wastes from lime and lime-soda ash softening plants, sodium zeolite softening installations and filter washwater operations. The report contains data on the chemical character of softening, filter washwater, and brine stream wastes. The softening sludge disposal methods considered include lagoon storage, discharge to water courses, drying and dewatering, and lime reclamation. Information is provided on proposed lime recalcining facilities and equipment and the advantages and problems associated with this operation. The pollutional effects of wastes discharges to watercourses and sanitary sewers are presented. The controlled dilution of brine discharges to a watercourse is considered more practical than disposal by uncontrolled dilution, evaporation ponds, and brine disposal wells. Several disposal schemes are suggested for filter washwater. Special consideration is given to the sedimentation of wastes at the Washington Surburban Sanitation District Willis School Plant.

AWWA Committee Report, "Disposal of Softening Plant Wastes, AWWA JOURNAL, 41, No. 9, pp 819-836 (1949).

Key Words: Brine disposal, Waste dilution, Lagoons, Lime reclamation

The pollutional effects of discharging lime and lime-soda sludge and sodium zeolite softening brine wastes to watercourses is discussed. Data on the physical and chemical characteristics of softening sludge and a brine waste sample has been presented. The results of a sludge disposal survey distributed to 21 states representing 371 lime or lime-soda softening plants are summarized. In addition to sludge disposal to lagoons and discharge to watercourses, the utility of municipal softening sludge to provide chemical coagulation in the primary treatment process at the Daytona Beach, Florida sewage treatment plant is referenced. Cost comparison data are presented for the Miami lime reclamation plant. Brine disposal techniques discussed include controlled and uncontrolled dilution in natural watercourses, evaporation ponds, and brine disposal wells. A summary of state health department responses to a survey querying zeolite brine discharges procedures is presented. An outline is prepared on how to plan for brine disposal.

Lawrance, C.H., "Lime Sludge Recirculation Experiments at Vandenberg Air Force Base," AWWA JOURNAL, 55, No. 2, pp 177-192 (1953).

Key Words: Water softening, Sludge recirculation, Lime-soda ash softening

This paper describes the testing of sludge recirculation as a treatment modification to eliminate the carryover of lime-soda ash floc, deposition of solids in clarifier effluent channels, and incrustation of filters at a water softening facility. Jar tests were conducted on sludge samples from the flocculators, clarifiers, and drying beds. The suspended solids concentrations were varied from 1 to 6%. These tests illustrated that sludge recirculation reduced the hardness, phenolphthalein alkalinity, and Langelier saturation index significantly when compared to raw water receiving only softening chemicals. The optimum suspended solids concentrations were from 5 to 6%. Fresh flocculator or clarifier sludge had more utility than dry sludge. The plant scale testing confirms the benefits of the jar tests. The optimum sludge source, optimum suspended solids concentrations, and sludge hydraulic characteristics were determined in the sludge recirculation experiments. Data are presented on the sludge carryover, softening efficiency, sludge volume index, and sludge composition in plant testing. A full-size recirculation system was put into plant operation.

AWWA Committee Report, "Purification Plant Waste Disposal," AWWA JOURNAL, 45, No.11, pp 1225-1237 (1953).

Key Words: Sludge disposal, Regulations, Filter plant, Coagulation basin

The purpose of this study is to provide a general review of the current methods employed to treat and dispose the wastes generated at water filtration and coagulation facilities. The physical and chemical character of the waste to be expected in grit chambers, plain settling or sedimentation basins, coagulation and sedimentation basins, and filter wash-water are defined. A questionnaire concerning current sludge disposal procedures and state regulations regarding waste disposal to water courses was sent to the chief sanitary engineer of each state and territory. The survey was systematically analyzed with respect to the arrangement of the purification plants, the sludge removal and disposal techniques, and filter washing disposal procedures. The utility of sludge as a fertilizer and the handling of sludge for landfill is discussed. Consideration is given to the biological effect of waste discharges to watercourses and the criteria established by the states to regulate these discharges.

Waring, F.H., "Methods of Lime Softening Sludge Disposal" AWWA JOURNAL, 47, No. 2, pp 82-84 (1955).

Key Words: Sludge disposal, Coil spring vacuum filter, Recalcining

The techniques employed to dispose of lime sludge from Ohio's 130 municipal lime-softening facilities include discharge to streams, dewatering in lagoons or sludge drying beds, discharge to abandoned quarries or city sewers, and vacuum filtration. Lagoons and drying beds are generally aesthetically undesirable and require periodic costly cleaning. Each of these dewatering methods are contingent upon available and isolated land sites. Detrimental effects of stream discharge included increasing the river pH, creating visible white turbidity, and depositing sludge blankets that may inhibit natural stream bilogical activity. The Ohio Water Pollution Control Board has classified lime sludge a pollutant. Recalcining is practiced in Miami, Florida, and Marshalltown, Iowa. A spring coil vacuum filter was installed in Gallion, Ohio, that produces a lime sludge cake of 8 pounds/ft^2/hr (dry solids) with a 6 to 7 inch mercury vacuum. Sludge thickening is recommended prior to filtration. The filtrate is economically recycled. The cake of 70% moisture can be further dried and used as a sanitary landfill. Vacuum filtration has utility for both sewage and industrial applications.

Krause, F., "Value of Sludge Calcining," AWWA JOURNAL, 49, No. 3, pp 327-330 (1957).

Key Words: Cost analysis, Calcining, Operating difficulties

Successful sludge calcining depends upon the sludge quality. Settling and clarification prior to softening may remove inert materials as silica and clay to increase sludge purity. A change in pH or solids separation by centrifugation can reduce magnesium contents. Pure calcium carbonate produced good lime. The carbonate slurries may harden in storage. Details of lime reclamation at Lansing, Michigan are provided. The process sequence includes sludge carbonation, thickening, centrifugation, conditioning, drying, burning and storage. Carbon dioxide is supplied from the calcining process. The drying gases are scrubbed. A cyclone distributes dried solids to storage and to mixing facilities to condition the sludge for drying. The calcium carbonate is calcined on a fluidized air stream in a rotary kiln furnace. Lime production versus cost is graphically presented. Operating difficulties discussad include proper equipment sizing, minimization of fuel requirement while maintaining proper furnace temperatures, and the need for continuous operation.

Eidsness, F.A. and Black, A.P., "Carbonation of Water Softening Plant Sludge," AWWA JOURNAL, 49, No.10, pp 1343-1351 (1957).

Key Words: Magnesium hydroxide, Carbonation, Settleability

The Hoover, Lykken-Estabrook, and centrifugation processes are available techniques to reduce the magnesium content of softening sludges. Sludge volume is dependent upon the physical characteristics of the suspended solids and the treatment process. The sludge settleability decreases and volume increases as the magnesium content increases. Sludge carbonation before centrifugation reduces the magnesium content by converting the hydroxide of magnesium to a soluble bicarbonate. Laboratory and pilot plant testing centered on determining carbon dioxide requirements for the hydroxide to bicarbonate conversion, the effect of detention time, the possible dissolution of calcium carbonate, and the improvement of sludge settleability and concentration due to carbonation. Magnesium removal curves are plotted for various carbonation levels and detention times utilizing sludge from the Dayton, Ohio, and Gainesville, Florida softening facilities. Carbon dioxide selectively converted 96% of the magnesium hydroxide to magnesium bicarbonate in 15 minutes. Magnesium hydroxide in raw and carbonated sludges influences sludge settleability and volume.

Nelson, F.G., "Discussion of Carbonation of Water Softening Plant Sludge," AWWA JOURNAL, 49, No.10, pp1351-1354 (1957).

Key Words: Magnesium, Carbonation, Settleability

This discussion describes the testing equipment and procedures utilized to evaluate the carbonation of softening sludges at Dayton, Ohio, and Lansing, Michigan. Carbonation is a simple and economical procedure to significantly reduce the magnesium concentration and improve solids settleability of softening sludge before dewatering and recalcination. Data are presented characterizing settling and magnesium removal efficiency at both facilities. Magnesium hydroxide was converted to the bicarbonate form at Dayton and to the normal carbonate form at Lansing. Preliminary investigations show that solid-bowl centrifugation may remove magnesium from the sludge cake at Lansing. Laboratory and pilot plant tests are recommended before designing carbonation and thickening equipment for magnesium removal and sludge thickening at other installations.

Doe, P.W., "The Treatment and Disposal of Washwater Sludge," Paper of Fylde Water Board, (1958).

Key Words: Sludge disposal, System parameters

This study describes an approach to dewater sludge to a solids concentration suitable for handling and disposal. Water clarification sludges vary in composition as well as quantity and concentration. Treatment systems must be flexible. Test results are given for freezing, filter pressing, porous ceramics filtration, and electroosmosis processing of clarification sludge. Experimentation shows preliminary thickening of sedimentation basin sludge to 6% solids should be considered. A thickening tank with a slow stirrer was designed. System parameters investigated include stirring speed, raw sludge concentration, sludge nature, tank shape, mesh used, paddle shape, temperature, and scaling effect. Preliminary test conclusions are enumerated. Washwater sludge can be thickened economically by slow stirring to 5% solids in a relatively short time. Further testing of filter pressing, heat treatment under pressure, and freezing was suggested to handle the pre-thickened sludge.

Crow, W.B., and Wertz, C.F., "Techniques and Economics of Calcining Softening Sludges," AWWA JOURNAL, 52, No. 3, pp 322-332 (1960).

Key Words: Cost comparisons, Water softening, Recalcination

The purpose of this study is to provide a review of recalcination technology and identify economic factors to be considered. These factors include reclamation plant capacity, lime transportation costs, sludge disposal expense, carbon dioxide cost, and fuel and power costs. Details of the rotary kiln, pellet-seeding, and flash calciner processes are presented and referenced to six water softening installations. A comprehensive description of the 80 ton capacity quicklime Miami lime reclamation plant is presented. Before rotary kiln recalcination, their lime sludge is thickened to 30% solids and dewatered by centrifugation to 66.8% solids. Carbon dioxide generated in the kiln is reused and the stack gases are scrubbed to minimize air pollution. Production, lime utilization and profit return on investment cost comparisons are tabulated for the first seven operating years. Plans to construct a lime reclamation facility at the Alexander Orr, Jr. Water Treatment Plant are disclosed.

Doe, P.W. and Benn, D., and Bays, L.R., "The Disposal of Washwater Sludge by Freezing," Institution of Water Engineers JOURNAL, 19, No. 4, pp 251-175 (1965).

Key Words: Sludge disposal, Freezing, Washwater sludge

This study describes design, layout, and operating data for a sludge treatment sequence. Clarification sludge was thickened by slow stirring and retention basin storage before freezing and thawing. Design principles include low capital costs, minimum building space, and future automatic operation of this facility. Plant testing concentrated on improving sludge thickness, freezing efficiency, and thawed sludge supernatant. Operational considerations include settling tank efficiency, sludge build-up, stirring speed variation, sludge extraction, retention tank design, and freezing process cycles. Testing of the freezing equipment generated design improvements that were incorporated into a new plant. Ignition of the thawed sludge followed by alum recovery at the Stocks plant concentrated the iron and showed other disadvantages. Frozen sludge lagoon effluent was mixed with sedimentation tank effluent to meet stream standards. Capital depreciation (plant, building), operation, maintenance, and power consumption costs are given. Recommendations are made for future treatment work.

Aultman, W.W., "Introduction to Waste Disposal - Water Treatment Plants," AWWA JOURNAL, 58, No. 9, pp 1102-1103 (1966).

Key Words: Waste disposal, Pollution control

More wastes are generated in the production of water for an ever growing population. The value of land for waste disposal facilities is steadily rising. Watercourses are needed for supply and not for waste transport. Increasing wastes volumes often impair water quality in river, lakes, and groundwater. The Federal government has enacted the Water Quality Act of 1965 to control discharges. An AWWA Committee was organized to study and report on the Disposal of Wastes from Water Purification and Softening Plants. This Committee's reports are enumerated. The Committee notes an increasing awareness of the public for pollution abatement and improved water quality. Their work concludes that lands are limited for ponding and lagooning wastes due to concentrated population centers. Local waste disposal research is suggested to provide treatment that will comply with state and federal pollution control legislation.

Howson,L.R., "Problem of Pollution," AWWA JOURNAL, 58, No. 9, pp 1104-1106 (1966).

Key Words: Waste disposal, Natural resources utilization

Each water treatment facility has waste disposal problems unique to itself. The magnitude of filter washwater and sludge disposal problems depends on the character and volume of the wastes and the assimilative capacity of the waste receiving watercourses. Water pollution is factual and depends on the effects discharges have on the stream and the degree of water quality degradation. Two examples illustrate the perspective in determining pollution. Sludge disposal to rivers may be insignificant during high river flow periods. Wash water can be properly diffused at outfalls, returned to the raw water at the mixing basins, and settled, with the liquid supernatant returned to the stream. The topic of waste discharges must be approached realistically. The utilization of natural resources for waste disposal must be considered when downstream users are not significantly affected.

Poston, H.W., "Federal Pollution Control," AWWA JOURNAL, 58, No. 9, pp 1108-1112 (1966).

Key Words: Water quality, Water pollution control program

The American Water Works Association issued a policy statement supporting a national program to preserve high-quality water supplies and reasonably restore the quality of polluted water supply sources. The Federal program provides aid to communities for waste treatment construction, enforces state and interstate pollution regulations, provides research on water quality problems, utilizes a river basin approach, promotes water quality standards, and provides technical assistance. Pollution control legislation was introduced in Congress to establish funds for sewage treatment plant construction, demonstration of new or modified water purification methods, demonstration of joint municipal-industrial waste treatment, and utilization of a river basin approach to pollution abatement. Water utility discharges are water pollution sources. These wastes impair water quality. The AWWA policy statement sets a trend for the water utility industry to control waste discharges.

Lyon, W.A., and Lazarchik, D.A., "Influence of State Quality Standards," AWWA JOURNAL, 58, No. 9, pp 1106-1108 (1966).

A pollution concerned society has been instrumental in urging stronger state and federal pollution control legislation. The state health agency regulates pollution legislation to protect streams in Pennsylvania. Water utility wastes are considered as industrial wastes. Waste sources include filter washwater and settling basin sludges. These wastes contain suspended solids and chemically coagulated flocs. Water quality discharge parameters include a 200 p p m suspended solids limit, carbon removal from washwater, chloride and sulfate concentrations of 250 p p m limit, soluble iron and manganese concentration of 7 p p m , and undissolved iron and manganese concentration conforming to the suspended solids limit. The concentrations are based on low flow conditions, 10% of the flow-duration curves. The Clean Streams Law resolves to restore streams to clean and unpolluted conditions. Streams uses are enumerated. Waste transport is not a primary use. The law has been enforced since 1959 at new and modified water treatment plants.

Remus, G.J., "Detroit's Waste Water Problems," AWWA JOURNAL, 58, No. 9, pp 1112-1116 (1966).

Key Words: Recirculated water, Waste wash water

The City of Detroit, Michigan, utilizes four wash water disposal techniques at its treatment facilities. These methods are direct discharge to the river, discharge to a sanitary sewer, recirculation and reuse of washwater, and clarification before discharge to a storm drain. Settling basin sludges and sanitary wastes are discharged to sanitary sewers. Data are presented on the flow characteristics and silt loading of the Detroit River and the quantitative and qualitative waste characteristics of the four treatment facilities. The waste washwater discharged to the river disperses within 25 feet, leaving no sludge deposits. Downstream water quality is unimpaired as the waste is chemically unharmful and bacteriologically superior to the raw water due to chlorination. This report states that economics govern the disposal method when these wastes have no detrimental effect on public health and downstream users. Limited cost, design, and bacteriological data are presented. The disadvantages of recycling are discussed.

ORSANCO Report, "Control of Wastewater Discharges from Water Purification Plants on the Ohio River," Staff Report, (1968).

Key Words: Water purification plants, Pollution abatement, Basin sludge, Filter washwater

This report describes waste discharge practices of water purification plants on the Ohio River. Highlights of ORSANCO member states waste control policies are provided. The effects of discharging sediment from raw water basins, sludge from settling basins, filter backwash water, and ion-exchange regeneration wastes from coagulation and softening plants to the Ohio River are described. The detrimental effects of these wastes include the formation of sludge deposits that inhibit aquatic life cycles,an increase in the river mineral content, and esthetic objections caused by color or suspended material. The report shows that ORSANCO states will require the construction of waste control facilities at both new purification plants and enlarged or improved existing treatment plants. A questionnaire concerning water-plant waste control policies was distributed to the ORSANCO members. A summary of this survey is included.

Bishop, S.L., and Fulton, G.P., "Lagooning and Freezing for Disposal of Water Plant Sludge," Public Works, 99, No. 6, pp 94-96 (1968).

Key Words: Lagoons, Freezing, Waste sludge storage, Water filtration plants.

The treatment of gelatinous hydroxide sludge and filter washwater from water filtration plants is a recognizable problem in pollution abatement. Alum recovery, vacuum filtration, and discharge of these wastes to sewerage systems are among some available treatment schemes. The advantages and disadvantages of these processes are discussed. Lagoons are shown to effectively settle and thicken sludges from the coagulation phase of the clarification process. Design parameters and sludge characteristics are given for the Shoremont Water Treatment Plant. In addition to providing waste sludge storage, the utility of lagoons for freezing the sludge as a treatment is discussed. The freezing process releases the water of hydration from hydroxide sludges and concentrates the sludge significantly upon thawing. This process is economical in climates where natural freezing could be used. At the Shoremont plant, the sludge concentration increased from 3.5 to 17.5% and the volume decreased considerably after freezing. Design considerations and operating procedures for lagoon-freezing operations are presented.

Benn, D., and Doe, P.W., "The Disposal of Sludge by the Freezing and Thawing Process," Paper of Fylde Water Board, (1969).

Key Words: Freezing, Thawing, Aluminum hydroxide sludge

This study defines the physical and chemical constituents of clarification sludge and an effective sludge treatment process. Clarification sludge is a thick jelly-like colloidal liquid containing organic, inorganic, and coagulant chemical material. The sludge is variable in color, thixotropic, and the organic material can be anaerobically digested. Sludge treatment processes include coagulant recovery, thickening, vacuum filtration, centrifugation, filter pressing, freezing, lagooning, and disposal into sewers or rivers. The steady slow freezing of sludge to 15°F creates pure ice crystals. These crystals are necessary for effective liquid-solid separation during thawing. A complete description of the freeze-thaw cycle, using ammonia as a refrigerant, is given. Latent heat is recovered and the thawed mixture flows by gravity. Important design considerations are listed. The process is clean, efficient, automatable, and produces an end product that can be handled. Cost considerations include high capital, operating and maintenance costs, plant depreciation costs, and power costs. Costs are listed for four freezing installations.

Sanders, P.V., "How We Solved Our Lime Sludge Disposal Problem," Public Works, 100, No. 2, pp 88-89 (1969).

Key Words: Softening plant, Solids disposal method

The City of Sioux Falls required additional sludge drying bed capacity to handle 29 tons (dry weight) per day of calcium carbonate sludge. Since the expansion of existing facilities near to the softening plant was impossible, plans were made to pump the sludge 4550 ft to an elevation of 50 ft and provide gravity flow 1900 ft at a 5% grade. The waste generated during the construction of the lagoons, providing 20 year storage, is being disposed of in a nearby drainage ditch. Farmers and fertilizer companies are removing this material as needed. The sludge is pumped by a 4-inch Model D L Wemco pump in a 6-inch pressure line to low elevation areas at present. The line to the new facilities will be kept free by periodic flushing with a clean water service. The Water Department is working on new disposal applications for the sludge including uses as soil stabilizers, crop and pasture fertilizers, and soil sweeteners.

Sutherland, Earl R., "Treatment Plant Waste Disposal in Virginia," AWWA JOURNAL, 61, No. 4, pp 186-189 (1969).

Key Words: Sedimentation basin, Filters, Water treatment plant wastes, Filter washwater

As part of a stream standards implementation program for the control of pollution caused by sewage, industrial, or other wastes, the Virginia State Water Control Board will provide specific provisions for the control of water treatment plant wastes. Four general water quality stream standards are provided. The study states that water plant waste characteristic vary considerably with raw water quality, treatment processes, cyclic filter backwashing and sedimentation basin cleaning. Bacteriological problems were not significant, but waste solids concentrations and turbidity were extremely high. The advantages of waste lagooning, washwater recirculation, and sand bed drying are presented. Design parameters and operating and capital costs are referenced to wastewater characteristics and plant capacity. Waste treatment by vacuum filtration, centrifugation, alum recovery, recalcining, and discharge to sewage treatment plants is considered. The board's policy is expressed and the applicability of this policy is discussed for new and existing water plant facilities.

Krasauskas, J.W., "Review of Sludge Disposal Practices," AWWA JOURNAL, 61, No. 5, pp 225-230 (1969).

Key Words: Sludge disposal, Water treatment plant wastes, Filter washwater

This review indicates that additional legislation will implement the Water Quality Act of 1965 and control the discharge of water treatment plant wastes to natural watercourses. The Washington Aqueduct Division conducted a survey of United States water treatment plants that showed that filter washwater and basin sludge were discharged to surface waters in the majority of plants. A list of research centers and treatment facilities studying treatment processes is provided. The study shows that the sludge composition of water plant wastes are highly dependent upon the source water and the chemicals utilized for treatment. Reference is made to several sludge disposal methods. These methods include discharge to streams, storm sewers and sanitary sewers, settling in lagoons, sludge freezing, centrifugation, vacuum filtration, filter pressing, wedge wire filtration, sand drying beds, and barging. Some design parameters, equipment operating characteristics and cost data are given for actual installations.

Doe, P.W., "The Disposal of Sludge from Water Treatment Plants," Paper of Fylde Water Board.

Key Words: Sludge disposal, Dewatering, Sludge reduction methodology, Prevention principles

This study relates the sludge disposal problem to economic and operational considerations while enumerating sludge reduction methods to alleviate the potential pollution from these wastes. The English Rivers Acts provide monetary penalties for discharging washwater, settling basin and lime sludge, and ion exchange regenerant to watercourses. Sludge prevention principles are enumerated. The choice of the process and raw water source can lessen sludge quantity or concentration. The advantages and disadvantages of lamella sedimentation basins, flotation tanks, slow stirring thickeners, and polyelectrolyte sludge conditioning are discussed. Lime and alumina recovery are referenced to specific plant locations. Design, operating, maintenance, and design considerations are mentioned for vacuum filtration, filter pressing, freezing and thawing, lagooning, disposal into sewers or rivers, and centrifugation processes. No universal treatment solution exists. Systems should be flexible and research information coordinated.

SECTION XI

INFORMATION RESOURCE DEVELOPMENTS

The state-of-the-art report on the "Disposal of Wastes from Water Treatment Plants, prepared by the Research Foundation in 1969, defined two areas in need of research. The first area was the generation of information that would be generally applicable to the water utility industry. This included the development of data on waste quantity and quality, and the suitability of waste treatment technology to effectively handle various types of wastes.

The second important area was the need to develop new or modified treatment technology to solve specific problems. Among the primary considerations, was the establishment of a uniform methodology to properly evaluate the dewaterability of sludges, using different treatment processes.

Information Clearing-House

The Report also recommended the establishment of a central information resource to coordinate information on continuing research and demonstration projects. The information clearing-house could organize, coordinate and disseminate research and development information to provide the direction for an industry-wide pollution control effort.

The AWWA Research Foundation has undertaken action to become a national clearing-house of information on the control of pollution caused by water treatment plant wastes for the benefit of the water utility industry. The first year of operation has been devoted to the simultaneous development of the structure of a clearing-house system as well as to the organization and coordination of information relating to sludge treatment and idsposal methodology.

It is intended that the publication of current information on pilot and plant scale research will accelerate the development and application of waste treatment technology for the entire water utility industry. The Foundation has attempted to identify projects completed, in-progress, or projected that will provide valuable reference material for individual researchers.

The cooperation of researchers, dealing with waste treatment problems of water utilities, is necessary for the overall development of a comprehensive inventory program. The failures and successes of the treatment technology require critical reporting to allow the systematic investigation of new or modified treatment alternatives. In this way, money and time will be channeled into constantly identified gap areas of research needs.

Related Projects

The Research Foundation has become involved in two related projects that may significantly alter the waste character of treatment plants. The first project is a study awarded to the Research Foundation by the Office of Saline Water, U.S. Department of the Interior. The program, titled "A Study of Using Desalting Techniques for the Improvement of the Quality of Water Supplies", will identify and evaluate applications of new processes which may be used by municipal water utilities to improve water quality. The wastes from desalting processes principally consist of concentrated brine solutions and pretreatment sludges from coagulation processes.

Desalination processes have potential applicability in making available new potable water supplies, especially in areas that must rely on brackish supply sources. Methods for the successful disposal of concentrated brine solutions will be necessary before municipalities can readily employ desalting technology. The information resource program will coordinate efforts between the two programs in relation to studies on the disposal of desalting facility wastes.

The second project is jointly funded by the Water Quality Office of the E.P.A.; City of Montgomery, Alabama; and the AWWA Research Foundation. The demonstration project is titled "$MgCO_3$ Coagulation in Treatment of Potable Water." This study involves a completely new integrated process of water treatment and will evaluate the efficiency and effectiveness of magnesium carbonate as a recycled coagulant to replace alum for the removal of turbidity and color. Data will be accumulated and incorporated into the information resource program.

Surveys Conducted

Two surveys were initiated through the Research Foundation. The first survey was sent to the state, interstate, and territorial authorized regulatory agencies. The purpose of this survey was to determine new information on the treatment requirements, disposal techniques, and responsibility of supporting and conducting research. The survey illustrated that the disposal of water treatment plant wastes to watercourses would be unacceptable in the majority of states unless these waste discharges could conform to the water quality or effluent standards set forth by each agency.

The second survey was sent to water treatment facilities in the United States and Canada. The purpose of this survey was to identify and inventory basic data (qualitative and quantitative)on waste handling and production. In conducting this survey, the need for the development of standard testing documents for sampling and analyzing water treatment wastes was demonstrated.

The Research Foundation, assisted by the Project Advisory Committee, was able to develop two new approaches for the systematic classification and reduction of wastes. A Project Sub-Committee is currently developing information on sampling, analysis, and categorization techniques for water plant purification and softening wastes. A separate Sub-Committee has developed documents to evaluate the applicability of polymers as primary coagulants, coagulation aids, and sludge conditioning agents. The testing of polymers at participating water utilities will be initiated and the results publicized.

Abstracts of Research Reports

The Research Foundation has collected and organized articles dealing with the treatment or disposal of water treatment plant wastes. These articles have been prepared in accordance with the Water Resources Science Information Center (WRSIC) specifications. These abstracted articles provide reliable reference material for the initiation of individual research for waste treatment process selection.

Project Advisory Committee

The collection and structuring of an information resource is, at best, a slow process. The development of reliable research and development data is an operation that requires concentrated efforts among researchers. A Project Advisory Committee, sensitive to the needs of the water utility industry, has utility in providing guidance and consultation to the Research Foundation which cannot be overemphasized.

Information on Foreign Research

The initiation of the resource program has been acknowledged by both national and international organizations. Correspondence has been extended to Canada and select foreign research institutions in Europe. Much can be gained from organizations such as the British Water Research Association (WRA). The WRA recognized the need to treat water utility wastes several years ago. A great deal of practical research effort has been conducted in England. Several plant size treatment facilities are operative there. Corresondence with domestic and foreign research organizations will be continued and expanded to identify additional development in pilot and plant scale processes. The WRA will cooperate with the Research Foundation in coordinating research information.

Expanded Information Program

The Foundation plans the continuation and expansion of the clearing-house functions in the coming year. Special reports on research information as identified through: Science Information Exchange; Water Quality Office, E.P.A.; and the Office of Saline Water, U.S.D.I., will be published. Information is being compiled presently from water and wastewater equipment manufacturers to identify equipment for dewatering or reclaiming water treatment wastes.

The Research Foundation looks forward to the cooperation of those associated with the water utility industry to submit information on their research activities. The development, publication, and transfer of significant new information will promote its application for the control of pollution by the water utility industry.

SECTION XII

ACKNOWLEDGMENTS

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The assistance of the Project Advisory Committee is gratefully acknowledged. Committee members provided expert guidance to the Research Foundation throughout the conduct of the study. This Committee includes:

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Illinois - Lake County Public Water District, Waukegan
Illinois - Northern Illinois Water Corporation, Champaign
Indiana - Indianapolis Water Company, Indianapolis
Iowa - Des Moines Water Works, Des Moines
Maryland - Washington Suburban Sanitary Commission, Hyattsville
Michigan - Metropolitan Water Department, Detroit
Missouri - City of Kansas City, Kansas City
Missouri - City of St. Louis, St. Louis
Missouri- St. Louis County Water Company, St. Louis
Missouri - Missouri Water Company, University City
Nebraska - Metropolitan Utilities District, Omaha
New Jersey - Garden State Water Company, Hamilton Square
New York - Monroe County Water Authority, Rochester
New York - Wanaka Water Company, Hamburg
Ohio - Ashtabula Water Works Company, Ashtabula
Ohio - City of Cincinnati Water Works, Cincinnati
Oklahoma - Oklahoma City Water Department, Oklahoma City
Pennsylvania - Philadelphia Suburban Water Company, Bryn Mawr
Pennsylvania - Chester Water Authority, Chester
Pennsylvania - City of Philadelphia Water Department, Philadelphia
Pennsylvania - Sayre Water Company, Sayre
Pennsylvania - Shenango Valley Water Company, Sharon
Texas - Water Utilities Department, Dallas
West Virginia - Huntington Water Corporation, Huntington
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SECTION XIII

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SECTION XIV

APPENDICES

Page No.

Research & Development Information Storage & Retrieval System 158

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Regulatory Agency Survey 166

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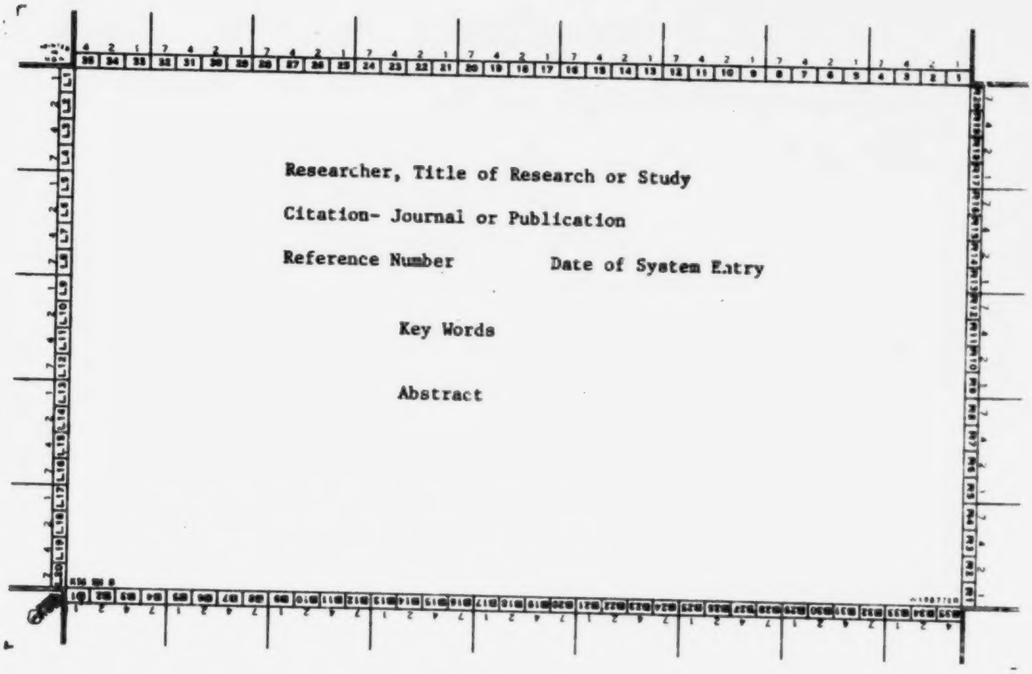
RESEARCH & DEVELOPMENT

INFORMATION STORAGE AND RETRIEVAL SYSTEM

Each article to be included in the retrieval system abstracts will be used to inform water utilities and others of studies pertaining to sludge treatment and disposal. The information will be stored on a McBee punch card as shown below. The back of the card will be used to store the abstracts.



Researcher, Title of Research or Study

Citation- Journal or Publication

Reference Number **Date of System Entry**

Key Words

Abstract

As each article is reviewed, the reviewer will classify the information on the R&D Information Storage & Retrieval System Punch Guide. The reports also will be indexed on 3x5 file cards, both by Author-Title and Title-Author alphabetically.

All information received will be listed chronologically to provide a ready reference to new information on the treatment and disposal of sludges from water treatment plants.

RESEARCH & DEVELOPMENT INFORMATION STORAGE AND RETRIEVAL SYSTEM

Basic Classifications:

1. Research (R-#)
2. Demonstration (D-#)
3. Pilot Plant Scale (PPS-#)
4. Plant Scale (PS-#)

Status:

9. Conceptually proposed or being developed
10. In-Progress
11. Completed

Developer:

13. Utility (Public)
14. Utility (Investor-Owned)
15. University or Educational Institution
16. Manufacturers of Equipment and Supplies
17. Association or Foundation
18. Consultant Engineer
19. Government, County
20. Government, State
21. Government, Federal
22. Government, Foreign
23. Government, Interstate Agencies

Supply Type:

24. Surface - River Water
25. Surface - Impounded Water
26. Groundwater
27. Surface & Groundwater
28. Estuarine
29. Ocean

Waste Sources:

30. Sedimentation Basin
31. Washwater
32. Desalting Pretreatment Sludges, Brackish
33. Desalting Pretreatment Sludges, Sea
34. Ion Exchange Regenerant Streams
35. Reverse Osmosis Brine Streams
L1. Electrodialysis Brine Streams
L2. Evaporator Brine Streams

RESEARCH & DEVELOPMENT INFORMATION STORAGE AND RETRIEVAL SYSTEM

Waste Types:	L9. Alum L10. Lime Softening L11. Lime-Soda Softening L12. Iron-Manganese L13. Iron Salt Coagulation L14. Polymers
Sedimentation:	L17. Intermittent Cleaning L18. Continous Cleaning L19. Solids Contact
Filtration & Exchange:	B5. Slow Sand B6. Rapid Sand B7. Dual Media B8. Multi-Media B9. Anthracite B10. Pressure Sand B11. Microstraining B12. Ion Exchange
Waste Treatment:	B16. Sedimentation B17. Lime Recovery B18. Alum Recovery B19. Lagooning B20. Vacuum Filtration B21. Drying Beds B22. Centrifugation B23. Freezing B24. Filter Pressing B25. Recycling B26. Chemical Coagulation
Solids Disposal:	B33. Discharge to Sanitary Sewers B34. Barging to Sea B35. Pipeline Transport

R1. Incineration
R2. Underground Injection
R3. Landfill
R4. Lagooning
R5. Other

Liquid Disposal:

R9. Recycling to Plant Intake
R10. Discharge to Waterways after treatment to meet effluent standards.
R11. Underground Injection
R12. Discharge to Sanitary Sewers

Project 2

"Information Resource for Water Pollution Control in the Water Utility Industry"

Water Utility Survey

Water Utility ______________ Source of Supply ______________

Location ______________ Official Reporting ______________ (Name and Title)

______________ Date ______________

I. Basic Data (Water Treatment Plant):

	Yearly		
	Average	Minimum	Maximum
Raw Water Turbidity (JTU)			
Raw Water Suspended Solids (mg/1)			
Raw Water Hardness (mg/1 as $CaCO_3$)			
Treated Water Hardness (mg/1 as $CaCO_3$)			
Raw Water TDS (mg/1)			
Treated Water TDS (mg/1)			
Water Treated (mgd)			
Chemicals Used (lbs/mg treated water)			
Alum			
Carbon			
Lime			
Chlorine			
Other (name)			
NaCl			

Special Comments: ______________________________

WATER UTILITY SURVEY

(Please Circle Reply)

II. Water Treatment Plant Waste Handling and Treatment

1. Are solids in sludge (slurry) withdrawals from Sedimentation Basins or Contact Basins additionally concentrated or thickened prior to disposal? Yes No

   By what Method? Settling mechanical thickeners in tanks

   freezing centrifugation vacuum filtration

   Other (Describe) ____________________

2. Are solids in filter washwater concentrated or thickened prior to disposal? Yes No

   By what Method? (Describe) ____________________

3. In what form are the suspended solids from water treatment plants basins at point of final disposal? Fluid Solid Semi-Fluid

   What is the Per Cent Dry Solids by Weight? ____________________

4. In what form are the suspended solids from filter washwater at point of final disposal? Fluid Solid Semi-Fluid

   What is the Average concentration of solids at point of final disposal - either _____mg/liter or _____% dry solids by weight?

5. What is the final disposal of water treatment plant sludge solids?

   Watercourse Lake Dry Creek Ocean Lagoons Sewer

   Landfill Agriculture Ground Treatment Recalcining Alum Recovery

   Other (Describe) ____________________

   a. Which method applies to solids from basins? ____________________

   b. Which method applies to solids from Filter Wash Water? ____________________

6. What is the final disposal of the liquid portion of water treatment plant wastes? (See above alternatives) ____________________

7. What is the final disposal of brines and other high TDS waste waters? ____________________

   What is the average TDS content of these waste waters, _____mg/l.

WATER UTILITY SURVEY

III. Waste Production and Waste Characteristics

1. Total Plant - Dry Solids Produced _____ lbs/M.G. water treated. (T.S. influent water + *Chemicals Added - T.S. treated water)

2. Density of dry solids produced _____ lbs./cu. Ft.

3. Volume water used for basin desludging, _____% of treated water.

4. Water used for basin desludging which is not reclaimed, _____% of treated water.

5. Volume water used for filter washing, _____% of treated water.

6. Filter wash water which is not reclaimed _____% of treated water.

7. Basin Sludge Concentration Data (typical samples)

   a. Average dry solids concentration at time of withdrawal from basins, _____% Dry Solids by Weight.

   b. Volume of sludge after 24 hr. settling and decantation of supernatant, _____% of original volume.

   c. Average dry solids concentration after 24 hr. settling and decantation of supernatant ___% Dry Solids by Weight.

   d. Suspended solids in supernatant after 24 hr. settling, _____ mg/l.

8. Filter Washwater Sludge Concentration Data (typical samples)

   a. Average dry solids concentration in filter washwater, _____ mg/l.

   b. Average dry solids concentration after 24 hr. settling and decantation of supernatant, _____ mg/l.

   c. Suspended solids in supernatant after 24 hr. settling, _____ mg/l.

*Chemicals added - chemicals that will result in a precipitate. Should include alum or Ferric salts, polyelectrolytes, activated carbon and lime and/or soda-ash. Should not include chlorine, salts of ammonia or lime used solely for pH correction.

WATER UTILITY SURVEY

III: Waste Production and Waste Characteristics (cont.)

9. Chemicals Analysis of Water Treatment Plant Wastes

	From Basins	Filter Wash Water
a. Waste solids after drying at 105°C	100%	100%
Volatile Matter	___%	___%
SiO_2	___%	___%
Fe_2O_3	___%	___%
Al_2O_3	___%	___%
$CaCO_3$	___%	___%
$Mg(OH)_2$	___%	___%
Remainder	___%	___%

b. Sludge as withdrawn from water treatment plant:

	From Basins	Filter Wash Water
C.O.D.	___ mg/l	___ mg/l
B.O.D.$_5$	___ mg/l	___ mg/l

c. Liquid waste at time of final disposal:

	From Basins	Filter Wash Water
C.O.D.	___ mg/l	___ mg/l
B.O.D.$_5$	___ mg/l	___ mg/l

Project 2

"Information Resource for Water
Pollution Control in the Water Utility Industry"

Survey of Regulatory Agencies

Statistical Information

1. Based upon your Agency's experience, please indicate, in order of magnitude, your concern regarding wastes from the following water treatment processes (use numerals 1 to 8 with 1 as a major and 8 as a minor concern):

_____ Coagulation

_____ Softening

_____ Iron-Manganese Removal

_____ Diatomaceous Earth

_____ Ion Exchange Regeneration

_____ Filter Backwash

_____ Desalination

_____ Microstraining

2. In determining treatment requirements for wastes from water treatment processes (question 1), does your Agency consider the following?

	Yes	No		Yes	No
TDS	___	___	COD	___	___
Settleable Solids	___	___	BOD	___	___
Suspended Solids	___	___	Chloride	___	___
pH	___	___	Color	___	___
Coliforms	___	___	Heavy Metals	___	___

3. Please indicate which of the following methods of sludge disposal would not be consistent with your Agency's regulations:

Discharge to sanitary sewers _____

Barging to sea _____

Pipeline transport _____

Incineration _____

Landfill _____

Agricultural Use _____

Please submit a copy of your Agency's regulations governing water treatment plant sludge.

Survey of Regulatory Agencies

Statistical Information (cont.)

4. Please indicate which of the following methods of liquid disposal would not be consistent with your Agency's regulations:

Recycle _____ Sanitary sewers _____

Stream Transport _____ Underground Injection _____

5. Please indicate whether your Agency requires water utilities to perform the following:

	Yes	No
a. Maintain records of waste production	___	___
b. Submit reports of waste production	___	___
c. Monitor waste receiving streams	___	___

If yes, reference which and enclose copies of records or reports.

Research

6. Please indicate, in your judgment, which of the following should be the major contributor in supporting research for treating wastes from water treatment plants (Question 1):

State government _____ Equipment Manufacturers _____

Federal government _____ Educational institutions _____

Water utilities _____ Consulting engineers _____

7. Please indicate, in your judgment, which of the following should conduct most of the research effort for treating wastes from water treatment plants (Question 1):

State government _____ Equipment Manufacturers _____

Federal government _____ Educational institutions _____

Water utilities _____ Consulting engineers _____

Survey of Regulatory Agencies

Regulatory

8. Please indicate, if the wastes from a water treatment plant could be reduced to the same form as the wastes in the original source water, would your agency accept the discharge of these wastes to a watercourse?

Yes ____ No ____

If not, what standards would you require?

* * *

Agency Completing Survey

Name ____

Title ____

Agency ____

Address ____

____

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15. Supplementary Notes

16. Abstract

This report describes the accomplishments of a program conducted to organize, coordinate, and disseminate information on new or modified sludge treatment technology for water treatment plant wastes. The reliable control of these potential pollutants is of increasing importance with the enactment and enforcement of more stringent pollution control legislation. The report contains information on research, engineering, plant operation, and regulatory aspects of the problem. A Project Advisory Committee provided recommendations for development of information resources, and assisted the Research Foundation in structuring an information clearinghouse. The report describes current research activities and new approaches for characterizing and reducing water treatment plant waste volumes. A program was initiated to evaluate the applicability of polymers as primary coagulants, coagulant aids, and sludge conditioning agents. A Sub-Committee was established to prepare uniform sampling, analysis and categorization techniques for water utility sludges. Each program is in progress. Surveys were distributed to water utilities and regulatory agencies to provide information on sludge treatment methods and requirements. The AWWA Research Foundation plans the continuation and expansion of this centralized information resource program. (Nardozzi - AWWA Research Foundation)

17a. Descriptors
*Sludge Disposal, *Sludge Treatment, Water Treatment

17b. Identifiers
*Information Clearing-house, *Information Resource, Surveys, Regulatory Information, Water utility sludge, Information Dissemination

17c. COWRR Field & Group 05D

18. Availability

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